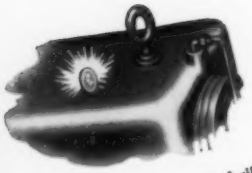
MARCH 16, 1959

Product Engineering

SHAPES FOR DEFENSE... see page 5



To demonstrate absence of vibration, a quarter was placed on the Cleveland unit. It remained upright through continuous clutching and declutching cycles and was still standing next morning after an overnight run-in test. Drive pictured at left was built by the Patton Mfg. Co., Springfield, O.

CLEVELAND-equipped mill drive offers vibration-free operation

IN a paper mill it is important that the output shaft of the gear reducer deliver smooth power to the paper-making machine. If this is not the case, the very sensitive draws between sections of the machine will not be maintained and the sheet of paper will break, causing an appreciable production loss.

In this new machine drive, smooth vibration-free power delivery is insured by its rugged transmission unit—a Cleveland Worm Gear Speed Reducer. Both drive makers and users know from years of experience that any Cleveland will transmit power from motor to its driven machine smoothly, quietly, continuously, dependably.

So wherever you need compact, right-angle speed reducers that will serve dependably under all conditions, specify Cleveland, the pace setter in power transmission since 1912.

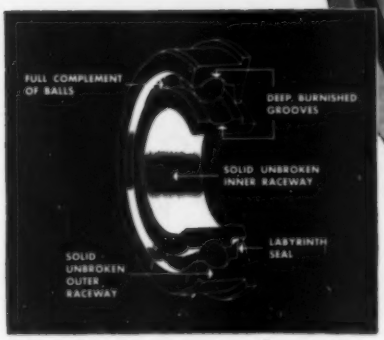
Write for Catalog 400 and the name of our representative near you. The Cleveland Worm and Gear Company, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.

CLEVELAND
Worm Gear
Drives

a low cost ball bearing of superior quality and greater durability

HEIM *Unibal*® BALL BEARINGS



Note this unusual construction. There is no other ball bearing like it!

Suitable for requirements ranging from the commercial field to many precision applications heretofore using conventional ground ball bearings.

Its simplified construction and unusual assembly method produce a bearing which has no loading slots, no split raceways, and no inserts . . . yet there is a full complement of balls for smooth operation and optimum bearing life.

Deep, unbroken, burnished ball grooves. with closer tolerances and improved finish, provide maximum capacity for radial and thrust loads.

Unibal Ball Bearings can be furnished in single row, double row, flanged or snap ring types in a wide range of widths and diameters . . . even down to extremely narrow widths.

Where closed type bearings are required, shields, mechanical or close, integral labyrinth seals on one or both sides are available.

Our Engineering Department will be happy to help you select the correct bearing for your application. Write for UBB folder showing dimensions, load capacities at various rpm.

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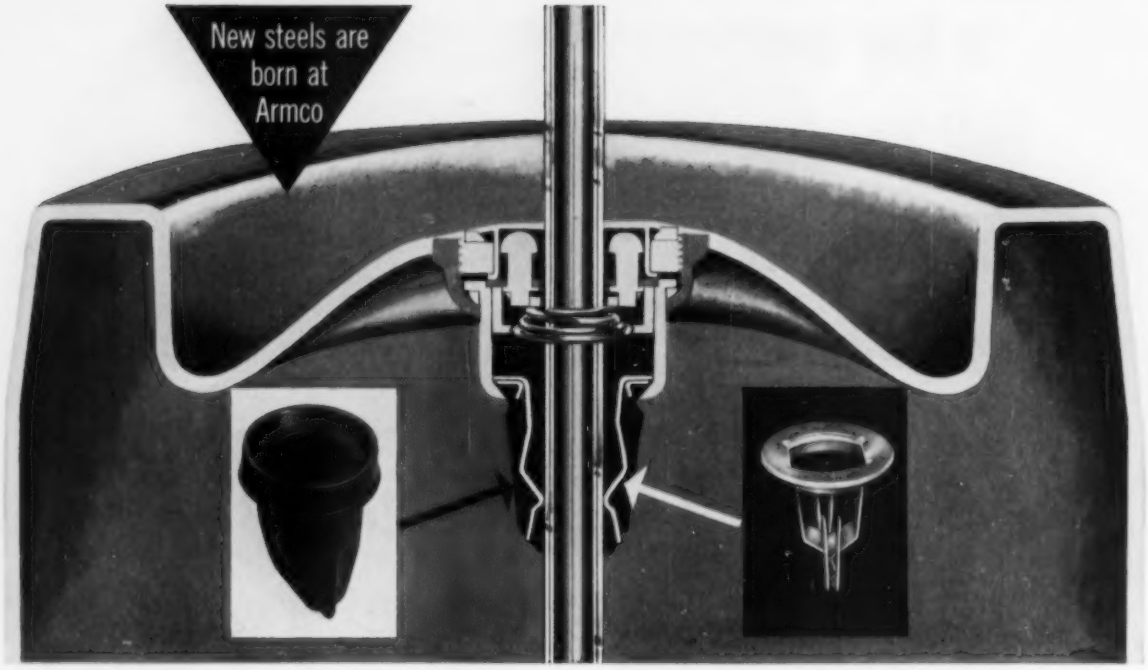
for Universal Bearing Corporation
P.O. BOX 486, FAIRFIELD, CONNECTICUT



How Seal Spring of Special Armco Stainless
Helps Keep Draft Beer Fresh

An unrelenting "squeeze" from a spring clamp made of special Armco 17-7 PH Stainless Steel helps this new beer keg seal maintain a leak-proof barricade against contamination.

The 17-7 PH spring is the "muscle" inside a molded rubber sealing unit that keeps a pressure-tight grip on the tap rod from the moment it's inserted. When the rod is removed, the spring snaps the seal shut. Thus draft beer is protected from air and contaminants throughout tapping and dispensing. And the same keg seal can be used time and again.

Many materials were tested by the designers of this unique tapping system—Champion Safe Tap Company, Cleveland, Ohio. Armco 17-7 PH Stainless was selected for the vital spring clamp because of its excellent spring properties and great resistance to relaxation despite repeated flexings.

Need corrosion-resisting springs?

Corrosion resistance is another top advantage of precipitation-hardening Armco 17-7 PH Stainless. This, combined with its strength and ease of fabrication, accounts for the growing use of this special grade for exacting spring applications.

Why not consider it for spring parts in *your* products? Armco 17-7 PH is produced in sheet, strip, plate, billets, bar and wire. For more information, fill in and mail the coupon.

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1529 Curtis Street, Middletown, Ohio
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Name _____ Title _____
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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN, RESEARCH AND DEVELOPMENT

MARCH 16, 1959 Vol. 30, No. 11

Numerical Integration Simplifies Complex Design * 50...
E E Ungar, of Bolt Beranek & Newman, Inc
Here's a tabular method for evaluating integrals, but surprisingly accurate. Author explains basic concepts, applies them in detail to six examples of beams and shafts with complex loading.

Better Linear Polyethylene Moldings 55...
R B Davidson, Celanese Corp
A growing family of plastics is overcoming that reputation of being "difficult to mold." But when designing for these polyethylenes you've got to know the ground rules. Here they are.

Design Features in New Products 58...
Locomotive runs on energy stored in a flywheel and converted to electric power; this light-control wins an Oscar from motion picture industry; lawnmower's floating cutter gives grass a fine shave; horizontal motor allows more headroom for vacuum cleaner.

Meet the "Insect-wing" Metal Panel 62...
W M Von Tannenberg, Buenos Aires
Author of the article is the transplanted German engineer who pioneered this latest technique for constructing twin-sheet panels. Their rigidity and light weight come from dimples and spot welds.

Design Your Own Dc Motors with Printed-circuit Rotors * 64...
R Page Burr, Circuit Research Co; R L Swiggett, Photocircuit Corp
A month ago we gave you first peek at this revolutionary concept. Now we show how to draw up specifications for these motors that do the job though they weigh less and cost less.

DESIGN FILE

11 Ways to Couple Tubes 70...
F F Wood Jr, Vitro Laboratories
An assortment of mechanical joints, including clamps, screws, threaded and welded sleeves.

Stresses in Continuous Beams 73...
Alexander Krivetsky, Bell Aircraft Corp
Problems of partial loading are quickly answered with these formulas and curves.

DEPARTMENTS

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Type B top; Type A center; Type S bottom. Other designs available.

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No wonder leading manufacturers of automatic coffee makers specify Stemco thermostats. For Stemco thermostats give long-life reliability that eliminates service headaches . . . are quickly, easily installed . . . are competitively priced. Our application engineering service is eager to help you solve your thermostatic control problem, whether it involves design, production or cost. Try us *now*.

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Interesting to Note . . .

1. Chance-Vought—Regulus II
2. Cessna T-37 Trainer
3. Martin Titan
4. McDonnel F4H
5. North American A3J-1 Vigilante
6. Northrop N-156 F Counterair Fighter (Canadian)
7. Raytheon Sparrow III
8. Northrop N-156 F Counterair Fighter (Spanish)
9. Chance-Vought F8U-3 Crusader III
10. Douglas Thor
11. Republic Thunderchief F-105

Missiles in the Sand

From the Wright Brothers trying their wings at Kitty Hawk, to the testing of missiles at White Sands, pioneer work on the airplane and its descendants has always been done in sandy areas. This characteristic is shown on our cover—even though the sand in the foreground came from our own loading platform in New York City, where it serves as insurance against ice. The picture also epitomizes the rate of change in aircraft design; the Regulus II in the background photo has already been phased out, as has the Crusader at lower right. The North American Vigilante at lower left, incidentally, has a rectangular fuselage cross-section—the fairing curves disappeared when square entrance ducts were applied to the twin jets. Note also the clearly defined pulses in the Regulus photo.

The cover shot, made by our own studios, is an interesting composition. The background picture was projected onto a screen for a 5-min. exposure. Then the projection screen was covered with black felt and the foreground lighted for a 15-sec exposure. Except the Cessna and Thor, all the planes and missiles shown are models made by Topping Inc, Akron, Ohio, and are newest additions to our chief editor's collection.

A Teacher to Be Remembered

It appears we have more authorities on education today than ever before. College presidents and professors are writing and speaking out, senators and governors are voicing their opinions on Congressional floors, even an admiral is vociferously telling America how to educate its young. When the din subsides, one thing will

(CONTINUED ON PAGE 7)

Product Engineering
A McGRAW-HILL PUBLICATION

March 16, 1959 Vol. 30, No. 11

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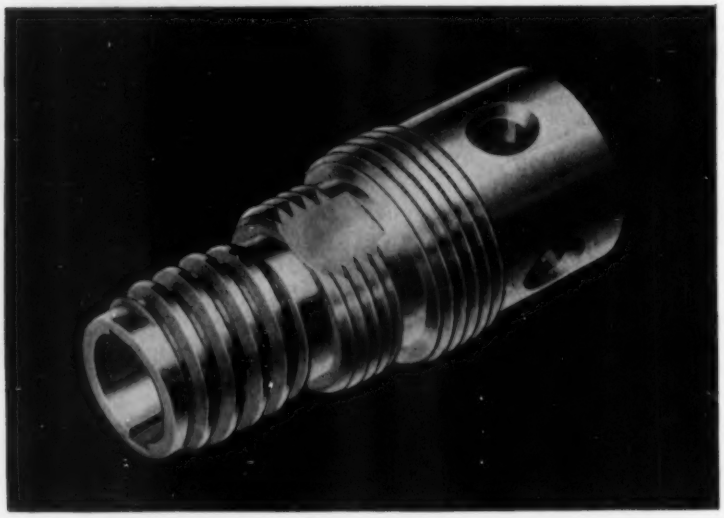
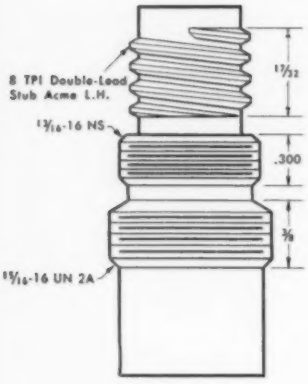
←CIRCLE 103 READER SERVICE CARD

COST CUTTING on tough jobs—like rolling a double-lead Stub Acme thread—may be easier than you think. Olson Mfg. Co. needed only a minor adjustment in a standard Anaconda rod

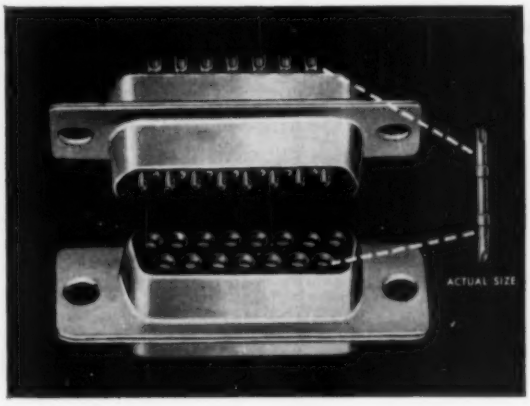




Rolling three threads *(drawing, right)* in two positions on a 6-spindle automatic meant cost savings for Olson Mfg. Co., Worcester, Mass. The Acme thread, however, posed problems. American Brass specialists suggested minor modification of standard Anaconda Free-Cutting Brass Rod to provide the extra ductility needed. The idea worked and the resulting valve spindle is shown above, about 1½ times actual size.

—or maybe you need a different alloy rod. The tiny connectors, right, have to be machined from .078" rod, requiring many precision form-cutting, drilling, slotting operations. So machinability is a vital property of the rod used—but so are adequate electrical conductivity, high strength, and fatigue resistance.

Cannon Electric, Los Angeles, makers of these electrical plug assemblies, had to find a rod with a delicately balanced combination of mechanical properties to provide the unfailing and continuous performance required. They found it in Anaconda Free-Cutting Phosphor Bronze-610 Rod, developed by American Brass metallurgists to combine the strength, resilience, fatigue resistance of phosphor bronze, and machinability approaching that of free-cutting brass.



MEETING the joint requirements of designers, manufacturing men, and buyers—to achieve high quality and performance while simplifying fabrication and cutting over-all costs—is an important function of American Brass technical specialists. For imaginative and practical help of this kind, see your American Brass Company representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

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emerge—there is a real problem. And its solution may never fully be realized until the educators, lawmakers and admirals are able to completely define the problem. They all seem to agree, however, that we need more and better teachers and schools. What and how the teachers will teach; where the schools should be built, and how they shall be organized seems to be the heart of the dilemma. One thing appears obvious—science, especially mathematics, will gain more and more prominence in the classrooms of tomorrow.

If there were a Hall of Fame for teachers, certainly Charles Lutridge Dodgson would hold high honors. Although a teacher by profession, and a good one, he'll probably only be remembered as a literary great. In public school, Dodgson was top in his class. He went to Oxford University in 1850. Under conditions of his fellowship he promised to become a minister and remain forever celibate—a condition he fulfilled all 66 years of his life. He became a don at Christ Church, a teacher at Oxford and a lecturer throughout England. Dodgson was a good mathematician but certainly not on a par with Newton, Einstein or Descartes.

Periods of insomnia gave him the opportunity to mull over algebra, plane geometry and trigonometry. He soon published a small book called *Pillow Problems* containing 72 problems he had worked out in bed without aid of pen or pencil. These problems, while elementary, required much concentration from his students.

Mathematical puzzles supplied another method to stimulate his students. One seemingly simple puzzle even baffled his contemporaries: "A weightless, perfectly flexible rope is hung over a weightless, frictionless pulley. At one end is a monkey, at the other a weight which exactly counterbalances the monkey. As the monkey climbs the rope, what does the weight do?"

Rev. Charles L. Dodgson

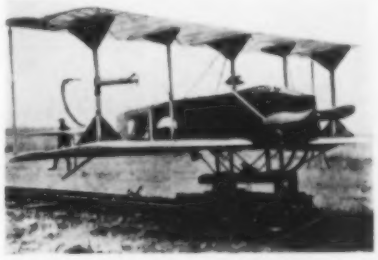
In his secluded life, Dodgson did little else but write and teach. The logic of math especially drew his interest. Numerical integration (p 50), equations presenting several variables (p 73), puzzles, or the simple feat of scoring a tennis tournament never ceased to fascinate him. At least 900 separate items were published by Dodgson, some devoted solely to children. Oddly enough, despite all his textbooks and studies on math, he is remembered for none other than a children's fantasy, *Alice in Wonderland*, written when he was 33 under his pen name, Lewis Carroll.

Plastic Under Pressure

When John Wesley Hyatt collected a $10,000 prize for developing a cellulose substitute for ivory billiard balls 91 years ago, he set off a reaction that has brought literally billions of dollars to the coffers of chemical companies (*PE—Nov '56, p 7*). The importance of plastics was slow being realized, but now it is one of our biggest industries. Every now and then a new plastics development provides new applications and more dollars. Such a major development occurred in 1935 when a laboratory accident led to the discovery of polyethylene (p 55), one of the most useful of modern plastics.

Imperial Chemical Industries Ltd had undertaken a series of experiments with ethylene and, since most of the work involved high pressures, a special laboratory was built. In March 1933, R. O. Gibson and E. W. Fawcett experimented with a mixture of ethylene and benzaldehyde. A waxy, white solid was obtained which was presumed to be a polymer of ethylene. Under high pressure the material exploded and the experiment was shelved. Two years later J. E. Paton found that when carbon monoxide reacted with aniline, a solid formed. Next he decided to try carbon monoxide and ethylene, keeping in mind the explosion that led his predecessors to abandon their ethylene experiments. Even with great care something went wrong. There was a defect in Paton's pressure apparatus and instead of a constant high pressure there was a pressure drop. When the breakers were disassembled, Paton found a small amount of white powder in a vessel. This strange unexpected substance could be cold-drawn like nylon, could be molded, was an excellent insulator. Polyethylene had been discovered.

Wanted— a Stable Torpedo



During the Civil War the Navy first realized the importance of the torpedo as a tactical military weapon (*PE—Nov 10 '58, p 5*). It took many more years of trial and error, however, before a satisfactory torpedo was developed. The principal problem, stabilization, was not solved until 1896—and then strictly by accident. What Navy wanted was a fast torpedo that would be driven underwater on a straight course. Early models failed miserably but when engineers were experimenting with the Howell Automobile torpedo, they decided to try harnessing the inertia of a flywheel to the propulsion mechanism, as in the mine car described on page 58. For a few hundred yards, it worked fine. The high degree of stability was so good they wanted to find out why.

The gyroscopic effect of the flywheel had effected stability, and from that day the gyro became the heart of the torpedo. Soon gyroscopes became so sensitive they were built into pilotless aircraft. Shown above is the first airplane designed and built to fly without a pilot.

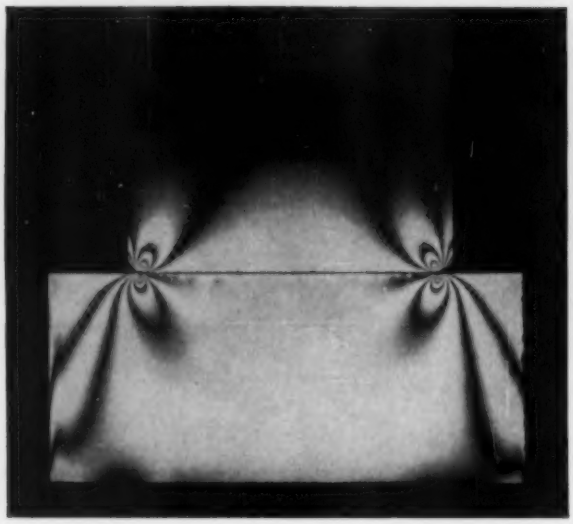
After this Sperry-Navy craft was catapulted from a track it would climb to a predetermined altitude, fly a preset course, then dive on the target and release an underslung torpedo. In today's terminology it would be called an intermediate-range guided missile. It only had a range of 100 miles, but in 1917 that wasn't bad.

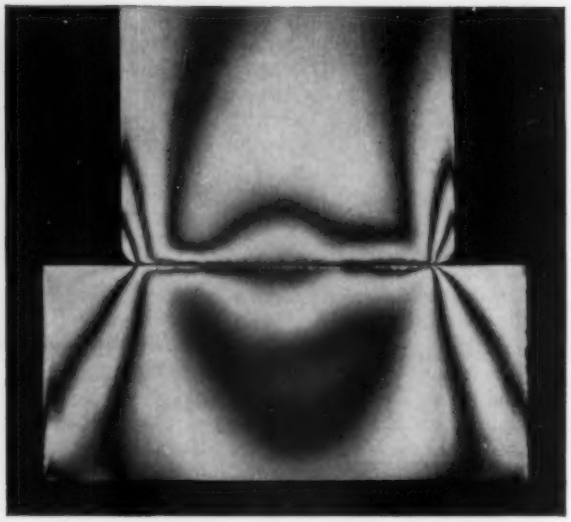
—Benedict A Leerburger Jr

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

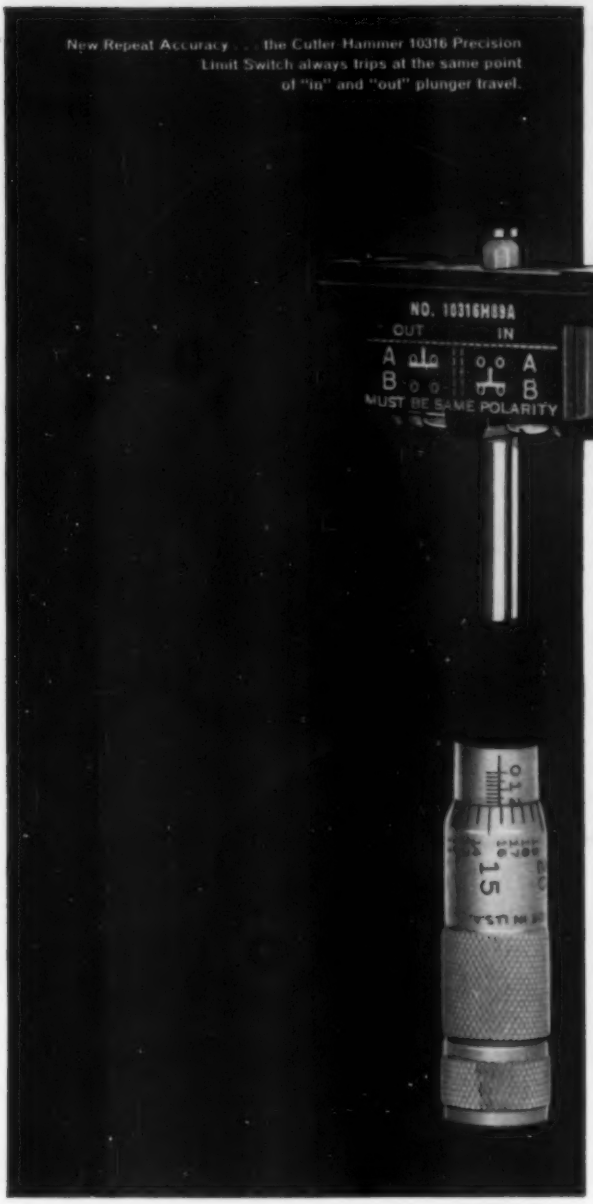
Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN


New Repeat Accuracy . . . the Cutler-Hammer 10316 Precision Limit Switch always trips at the same point of "in" and "out" plunger travel.
NO. 10316H89A
OUT
IN
A
B
MUST BE SAME POLARITY

NEW HIGH PRECISION in a NEW PRECISION LIMIT SWITCH

- **LASTS 10 TIMES LONGER**
- **CAN'T TEASE**
- **TRIPS REPEATEDLY AT PRECISELY THE SAME POINT**

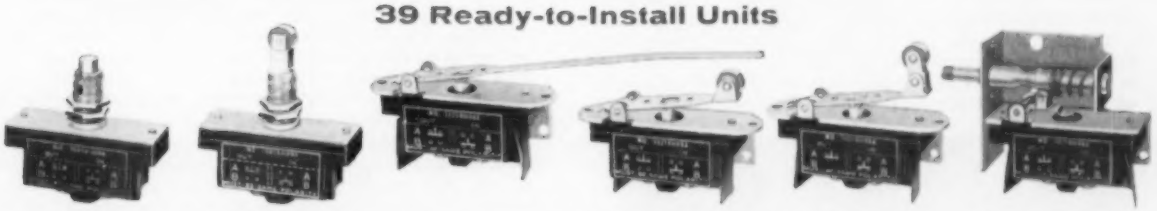
The new 10316 will change your ideas about what an industrial duty precision limit switch can do.

Comparative tests proved the 10316 provides ten times greater life. It could not be teased. And it always fired at exactly the same points of "in" and "out" plunger travel. Prove it yourself! You'll discover a *new high* in electrical and mechanical life, the sureness of repeat action, the utter dependability of the Cutler-Hammer 10316 Precision Limit Switch.

Three dimensionally identical switch bases are available. Double circuit switch is normally open—normally closed. Single circuit switches are either normally open or normally closed. A wide variety of operators, with various individual mountings, provide easy-to-install units meeting practically every type of application.

If you use precision limit switches at all, the 10316 is for you. Know the difference—write for fully explanatory Pub. EA 154-F 249 Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

39 Ready-to-Install Units



Plunger Operators for in-line operation with controlled overtravel.

Roller Plunger available for in-line or right angle operation.

6" Lever can be formed on-the-job to satisfy unusual needs.

Roller Lever with either right or left-hand operator. Operates in both directions.

1-Way Roller Lever operates in one direction, by-passes in the other.

Cabinet Door Perfect control panel safety interlock . . . available with single or double contact block operators.

CUTLER-HAMMER CONTROL C-H

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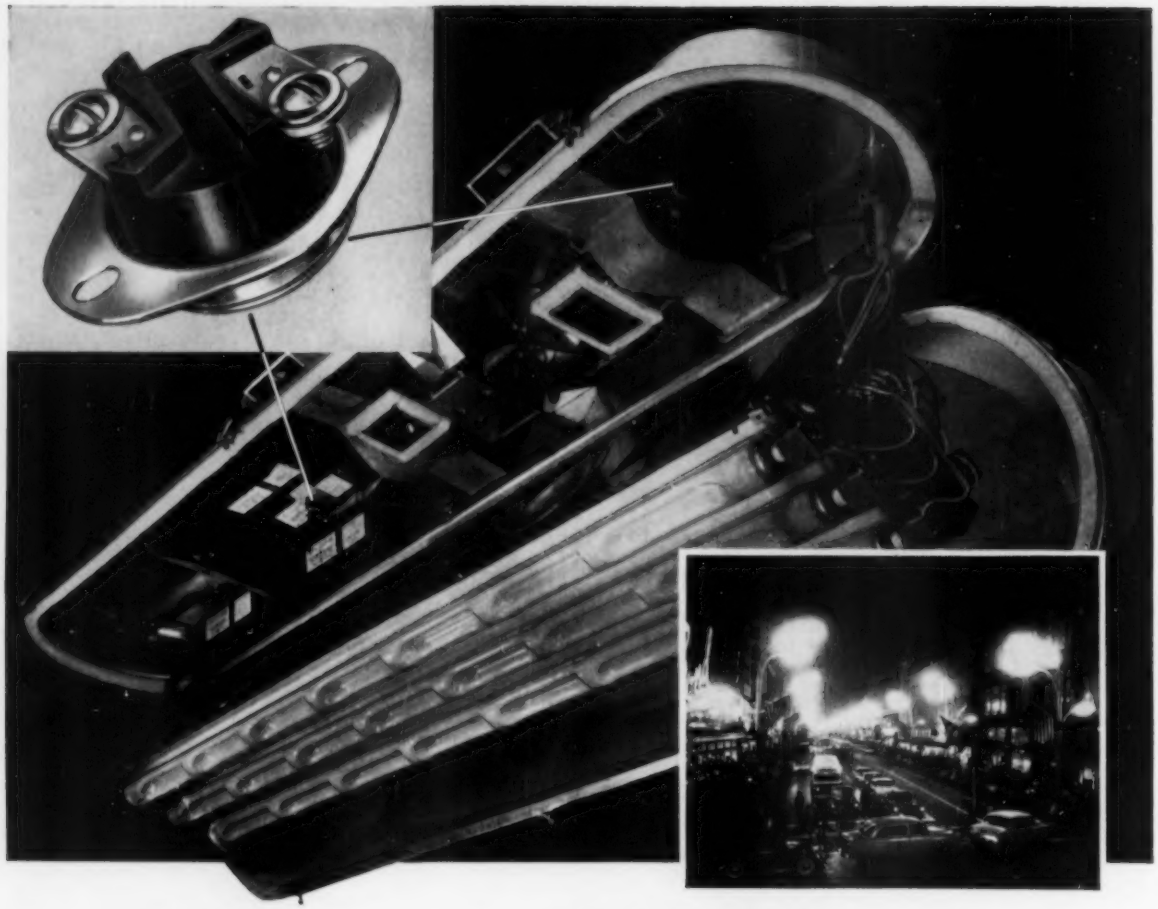
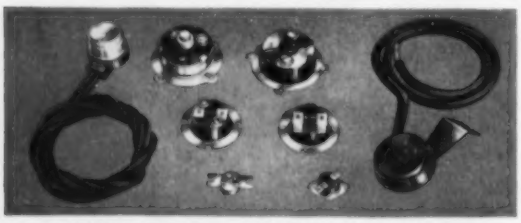


KLIXON Snap-Acting THERMOSTATS provide POSITIVE TEMPERATURE CONTROL in General Electric's Fluorescent Luminaire

Engineered by the Outdoor Lighting Department of General Electric Company, Chicago's State Street Relighting Project is the brightest, most modern street lighting arrangement ever attempted.

280 G. E. Form 606 street lights with 6-foot "Power Groove" lamps, mounted four to a pole, are used in the project.

To safeguard their product against excessive temperature, General Electric uses two KLIXON 202 Snap-Acting Thermostats in each light. These help improve lighting efficiency by turning on and off a fan-cooling system at specific temperatures.



Typical KLIXON Snap-Acting Thermostats used in many applications by original equipment manufacturers.

KLIXON Snap-Acting Controls are used because they respond to temperature change quickly and with accurate repeat performance; they have ample capacity to handle the required electrical loads; and their calibrations stand up in the face of severe environmental conditions.

General Electric Company, Outdoor Lighting Department, is another of the hundreds of leading manufacturers specifying and using KLIXON Controls. These controls are available in both sealed and open construction in a wide variety of types and sizes. Fixed temperature settings are custom calibrated at the factory to meet specific application requirements.

Our Field Engineers will gladly help you make test applications of KLIXON Controls at your request, or send for *new* KLIXON Commercial Thermostat Catalog and get acquainted with the application possibilities on your products. No obligation, of course.

METALS & CONTROLS CORPORATION

Versailles Products Division

3803 N. Main St., Versailles, Ky.

KLIXON®

6 alloys=95% of today's engine bearing requirements

Steel backs, lined with:
FEDERALOY A-200 Aluminum alloy
FEDERALOY H-24 Copper alloy
FEDERALOY H-35 Copper alloy
FEDERALOY H-50 Copper alloy
FEDERALOY B-100 Tin-base babbitt
FEDERALOY L-200 Lead-base babbitt

This group of sleeve bearing alloys permits the engineer to design for all conventional commercial applications. At the same time, he can meet his performance and cost requirements.

Each of these alloys has been thoroughly proved and accepted by leading engine builders. Our production of millions of sleeve bearings each year assures you of the highest quality, efficiency and economy. Complete engineering service. A copy of the "Sleeve Bearing Design Guide" will be sent free on request. Address:

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11043 SHOEMAKER, DETROIT 13, MICHIGAN

Spacer Tubes

Bimetal Bushings

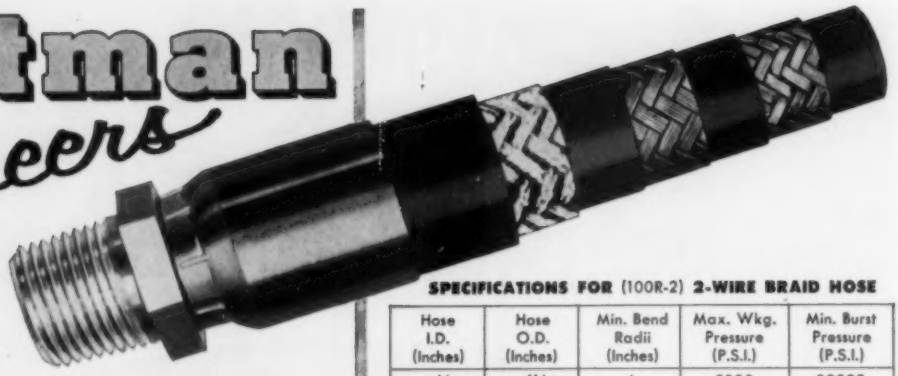
Plain Bushings

Precision Thrust Washers

FEDERAL Mogul SINCE 1899

Eastman

engineers the way TO HIGHER PRESSURES



Eastman engineering is making possible ever-increasing advances in hydraulic pressures through:

- Couplings designed to exceed minimum *burst* pressure —four times actual working pressure.
- Hydraulic application of couplings to hose, assuring maximum grip—within specified hose tolerance.
- Maximum orifice—designed to improve fluid flow, reduce friction and increase power delivery.
- More rigid testing of completed assemblies to reveal additional opportunities for improvement.

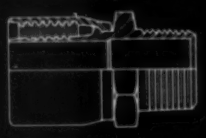
Let Eastman engineers help you increase the "power-performance ratio" of your product to improve *your* competitive position in *your* field.

SPECIFICATIONS FOR (100R-2) 2-WIRE BRAID HOSE

Hose I.D. (Inches)	Hose O.D. (Inches)	Min. Bend Radii (Inches)	Max. Wkg. Pressure (P.S.I.)	Min. Burst Pressure (P.S.I.)
¼	11/16	4	5000	20000
⅜	27/32	5	4000	16000
½	31/32	7	3500	14000
¾	1 ¼	9½	2250	9000
1	1 5/16	9½	1875	7500
1 ¼	2	16	1625	6500
1 ½	2 ¼	20	1250	5000
2	2 ¾	22	1125	4500

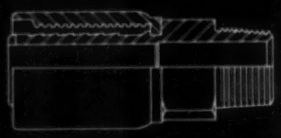
PERMANENTLY ATTACHED COUPLINGS

For 2-wire braid hose. Offers maximum coupling strength, strong hose attachment and improved orifice for rapid, friction-free fluid flow. For working pressures up to 5000 psi. See Pages 10 and 11.



HIGH PRESSURE COUPLINGS

For EXTREME high pressures up to 7000 psi working pressure. Eastman engineered for greater power delivery and performance. For specifications and sizes, send for New Eastman Bulletin 200, below.

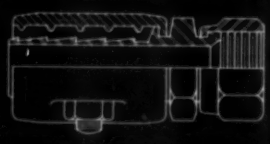


2-PIECE REUSABLE COUPLINGS

For 2-wire high pressure hose up to 5000 psi working pressure. Increases serviceability of your equipment through easy replacement in the field. See new Bulletin for complete details.

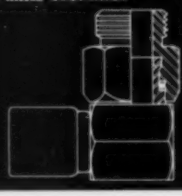
CLAMP TYPE COUPLINGS

Accurate machining assures alternate positioning of clamp ribs between each barb of insert—creating, exclusive Inter-Lock grip—available to you only through Eastman. Pages 14 and 15.



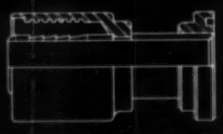
SWIVEL "O" RING MALE COUPLINGS

Permits easy assembly in close quarters, easy positioning of hose in 45° and 90° angles. Economical, reduces number of threaded connections. Dimensional drawings, sizes, and specifications in new Bulletin.



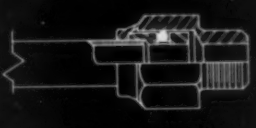
FLANGE HEAD COUPLINGS

Offer advantages of permanent hose attachment plus Split Flange Head Couplings with 0° to 90° stems. Economy plus user convenience. Specifications and sizes listed in new Bulletin.



TUBING ASSEMBLIES

Swivel Male "O" Ring Tube Nut used on tubing assemblies. Eastman offers formed tubing with beaded or flared ends—to your requirements. Specifications and sizes on Page 30.



Eastman
first in the field
MANUFACTURING COMPANY
Dept. PE-3, MANITOWOC, WISCONSIN

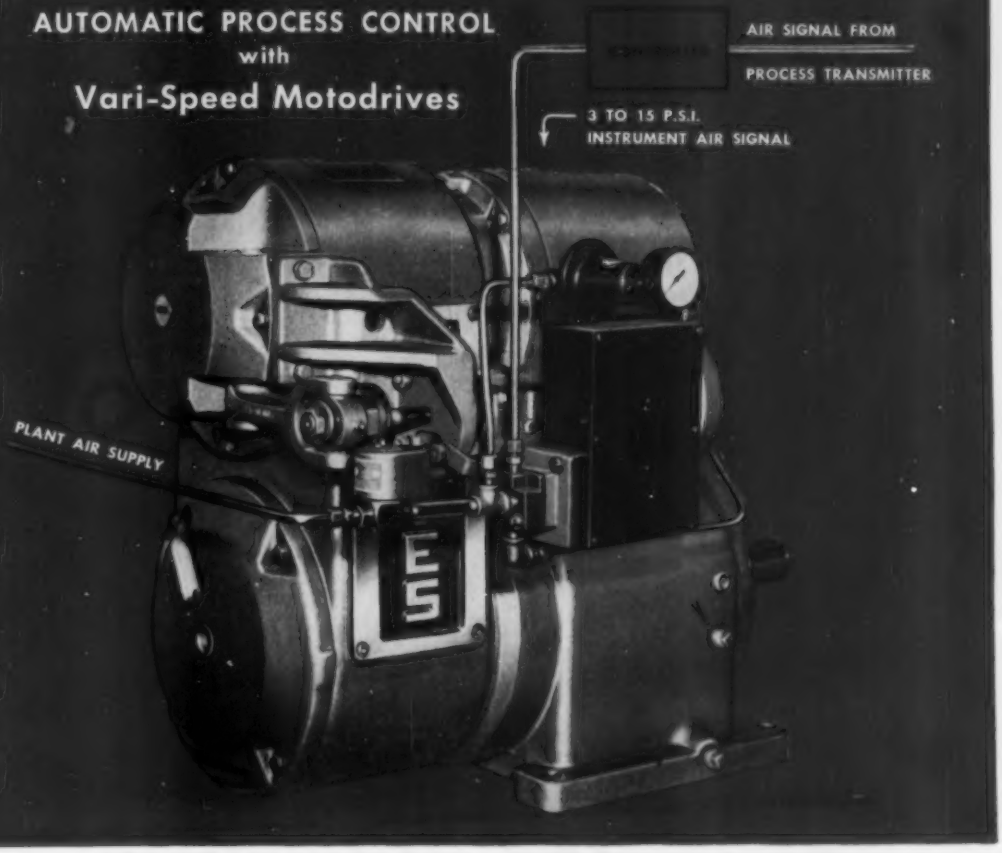
Write FOR YOUR NEW BOOK— WITH THAT NEW LOOK!

- A NEW Service Concept.
- A NEW High in Convenience.
- A NEW Ease in Specifying— according to your pressure requirements.

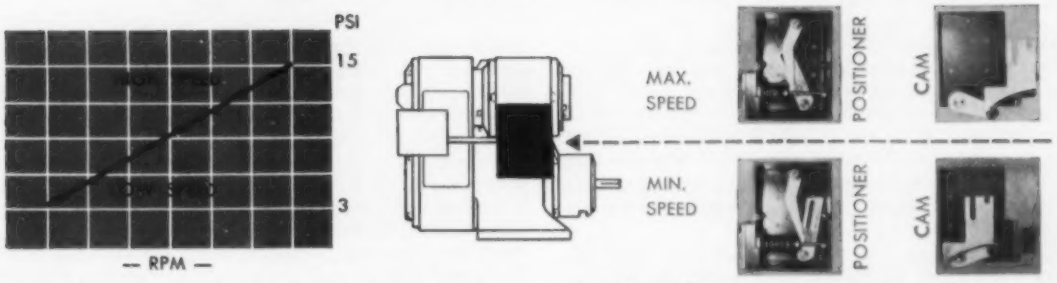
SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

REEVES

AUTOMATIC PROCESS CONTROL
with
Vari-Speed Motodrives



Sensitive Speed Reaction to Controller Signals ... Straight Line Variable Speed Output



● REEVES AIRtrol, in an open or closed loop system, automatically and continuously corrects operating speeds to compensate for variations in materials or energy (i.e. temperature, liquid level, density or flow).

As the final control element, the pneumatically-controlled Motodrive assures sensitive and stable control throughout the speed range.

Linear speed output is a result of the exclusive cam design. The AIRtrol responds to a 3 to 15 p.s.i. pneumatic signal, and is adaptable to all standard process instrumentation.

The AIRtrol is available on all REEVES Motodrives . . . hundreds of assemblies from ¼ through 40 hp., 2:1 through 10:1 speed range, and 1.7 through 4660 rpm.

For examples of AIRtrol in process control systems, write Dept. K 39 for AIRtrol Instrumentation Data Sheets.

VARI-SPEED MOTODRIVE
VARI-SPEED MOTOR PULLEY
VARIABLE SPEED TRANSMISSION

REEVES PULLEY COMPANY
Division of RELIANCE ELECTRIC AND ENGINEERING CO.
COLUMBUS, INDIANA
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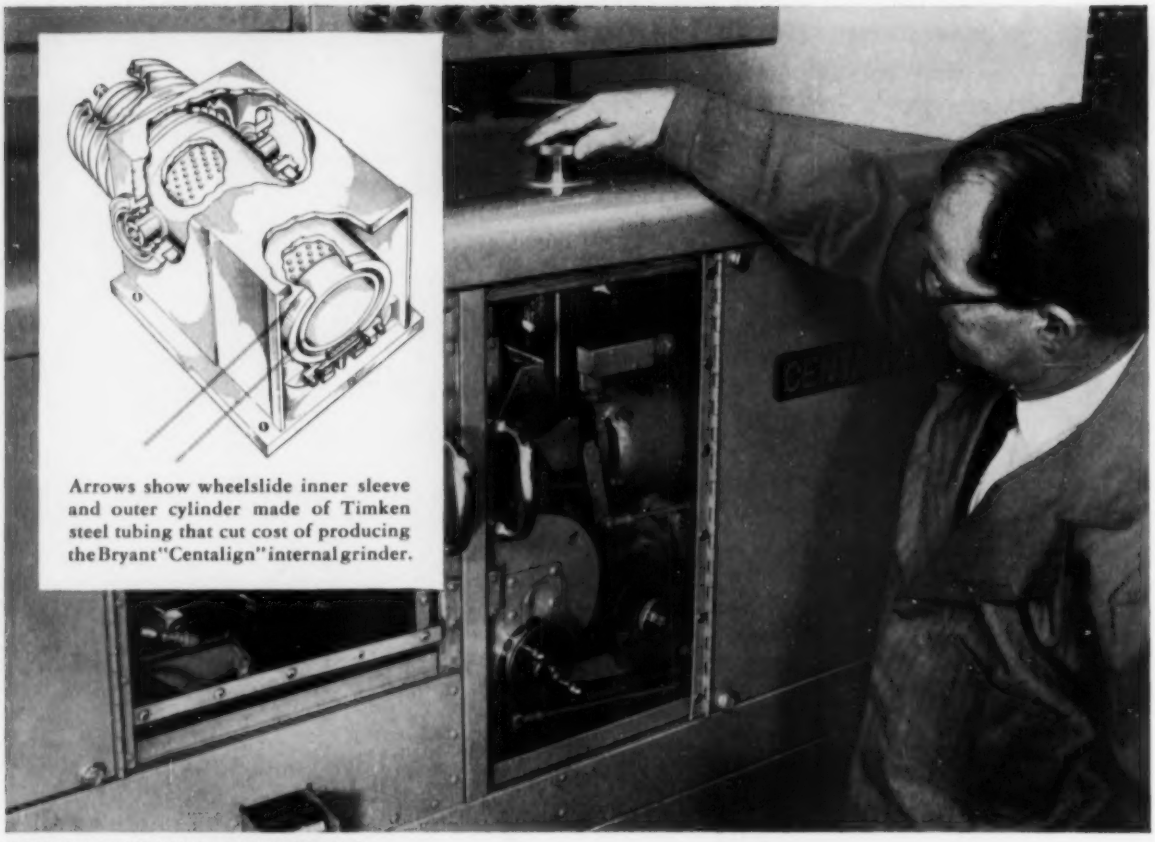


Arrows show wheelslide inner sleeve and outer cylinder made of Timken steel tubing that cut cost of producing the Bryant "Centalign" internal grinder.

BRYANT CHUCKING GRINDER CO.

Saves 45% with switch to TIMKEN® steel tubing

ENGINEERS at Bryant Chucking Grinder Co. wanted to reduce the cost of producing this "Centalign" internal grinder. They blamed high costs on spoilage due to weld checking and excessive machining time of the inner sleeve and outer cylinder of the wheelslide. When they consulted Timken Company metallurgists, these experts studied all angles of the problem. And they recommended a change to a certain grade and size of Timken® seamless steel tubing. Here's what happened.

Because the tubing was perfectly suited to welding, checking was ended. And costly machining time was cut because excessive stock removal was eliminated. The tubing was the right size for the job. They cut production costs 45%! What's more, the tubing had the desired hardness and grinding properties, responded uniformly to heat treatment.

Timken seamless steel tubing gives better quality finished products because of the way we make it. We forge a solid round over a mandrel, thoroughly working the metal inside and out. This rotary piercing operation gives the tubing its fine forged quality and uniform spiral grain flow for extra strength. Careful control keeps this quality uniform from tube to tube, heat to heat, bar to bar.

To help cut costs on your hollow parts jobs, let our engineers recommend the tube size most economical for you. It's guaranteed to clean up to your finished dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". Makers of tapered roller bearings, fine alloy steels and removable rock bits.

Timken alloy steel and seamless tubing is available from warehouse stock in 44 cities in the United States. Call your local Timken Company sales office for the name of your nearest Timken steel distributor.

TIMKEN® *Fine Alloy* STEEL

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS STEEL TUBING

LOWER-COST DRIVES

. . . one of 3 advantages you can choose from when you specify premium V-belts reinforced with DACRON®

POLYESTER FIBER

DRIVE COST COMPARISON
(Equal Rated HP Capacity)

STANDARD V-BELTS

MOTOR SHEAVE	MILL SHEAVE	V-BELTS
10 p.d., 5C groove	20 p.d., 5C groove	5 standard C144
Width of sheave—5.375"	Width of sheave—5.375"	"Matched Belts"
$38.68	$64.08	$48.00

TOTAL COST $150.76

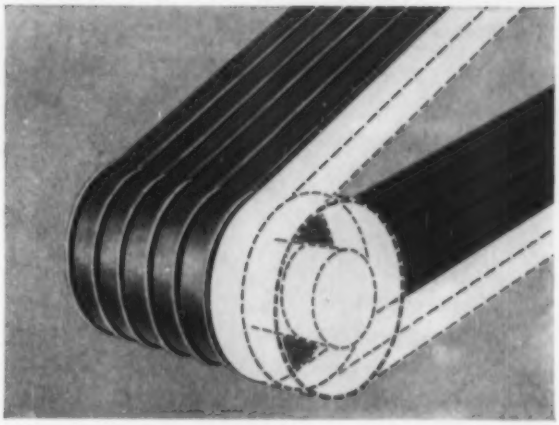
V-BELTS REINFORCED WITH "DACRON"

MOTOR SHEAVE	MILL SHEAVE	V-BELTS
10 p.d., 4C groove	20 p.d., 4C groove	4 premium C144
Width of sheave—4.375"	Width of sheave—4.375"	"Matched Belts"
$32.62	$54.03	$52.72

TOTAL COST $139.77

TOTAL SAVED PER DRIVE— **$10.99**

DRIVE COST GOES DOWN when your design calls for premium belts made with DACRON. Fewer, stronger belts mean you can use smaller, less-costly sheaves—so total cost is lower.



5 BELTS DO THE WORK OF 7 in a typical drive using premium V-belts reinforced with DACRON. Great strength of DACRON allows freedom of design with fewer or smaller belts and sheaves . . . creates a compact, efficient drive.

UP TO 40% MORE HORSEPOWER with premium V-belts of DACRON makes them ideal for heavy-duty drives. And DACRON is *stable*—has 1/20th the moisture regain of rayon cord used in belts. This simplifies matching problems.

EXTRA STRENGTH in premium V-belts reinforced with Du Pont DACRON* polyester fiber offers solutions to major drive-design problems. Once installed, these belts continue to improve efficiency and economy. V-belts reinforced with DACRON are stable and resist stretch . . . there's less need for maintenance, less time spent in matching.

FREE BOOKLET tells the complete story of V-belts reinforced with DACRON. For your copy, fill out and mail the coupon below. Du Pont makes the DACRON fiber used by belt manufacturers in producing their finest-quality V-belts.

**"Dacron" is Du Pont's registered trademark for its polyester fiber.*

Enjoy the "Du Pont Show of the Month" on CBS-TV

DU PONT
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BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

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Wilmington 98, Delaware

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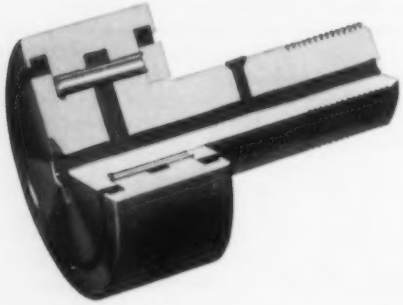
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4″ are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

engineered electrical products

McGILL®

precision needle roller bearings

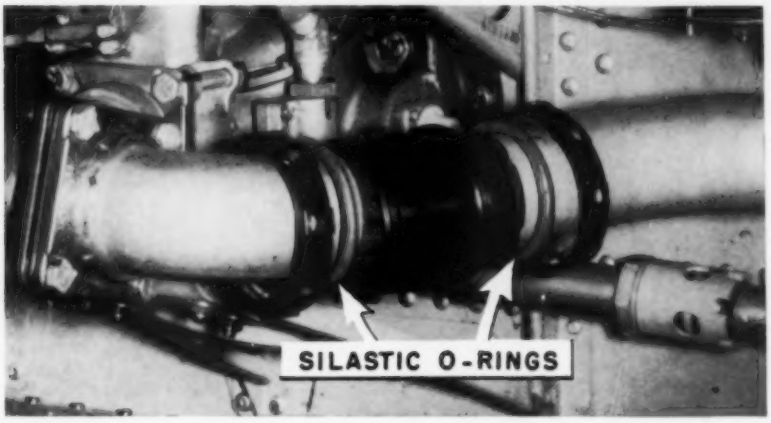
McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 201 NORTH LAFAYETTE ST., VALPARAISO, INDIANA

first in silicones

Dow Corning

SILICONE NEWS

for design and development engineers • No. 60



PREVENT FUEL LINE LEAKS

Jets will soon dominate commercial airways as more and more DC-8 Jetliners go into world airline service. Helping Douglas Aircraft write new commercial aviation history is Silastic® LS-53, the Dow Corning fluorocarbon silicone rubber.

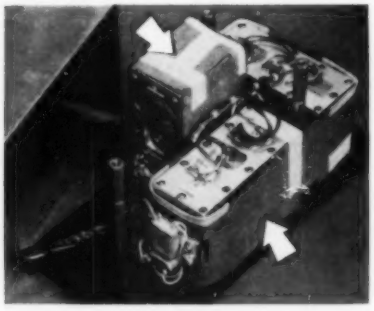
A DC-8 carries over 21,000 gallons of fuel. The hundreds of fuel line joints, connected by flexible couplings manufactured by On-Mark Engineering, Los Angeles, utilize approximately 1000 O-rings, ranging in size from 1″ to 4″ I. D. Keeping these flexible joints leakproof against jet fuels requires O-ring seals that meet the most rigid requirements for serviceability and reliability.

Douglas tested dozens of standard rubbery materials for fuel resistance, thermal stability, weathering, compression set and shrinkage. The tests were performed after the O-rings had been immersed in fuel for a designated period, removed, and allowed to dry out. The result was that only a special compound based on Silastic LS-53 met all service requirements. This material withstood 1,000,000 cycles of flexing without springing a leak.

Uniquely resistant to a wide variety of fuels, oils, solvents and chemicals, Silastic LS-53 is called for on an ever-growing number of specifications for sealing applications in the aircraft, automotive, electrical and petroleum industries. *No. 614*

TYPICAL PROPERTIES OF SILASTIC LS-53

Serviceable Temperature Range	**—80 to 500 F**
Compression Set, %	
22 hr at 300 F	**22**
Solvent Resistance, % swelled	
ASTM No. 3 Oil, 21 days at 300 F	**3**
Jet Fuel JP4, 15 days at 250 F	**18**



WRAP-AROUND HEATERS

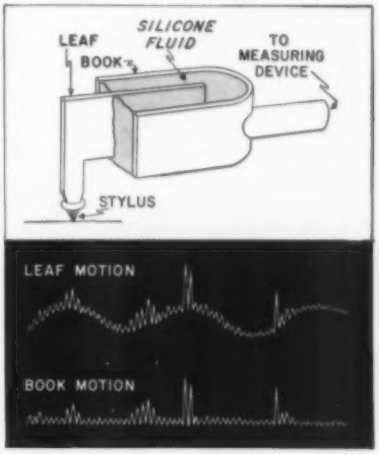
To develop a new, flexible strip heater that would be easy to install, engineers at Electro-Flex Heat, Hartford, Conn., capitalized on the electrical and physical properties of Silastic®, the Dow Corning silicone rubber.

This heater was especially designed to assure maximum operating efficiency of triaxial accelerometers built by the Avion Division of ACF Industries. The heater maintains the temperature of the accelerometer at 85 C despite exterior temperatures as low as —60 C. Simply constructed, the heater is a spread-out coil of resistance wire permanently sandwiched between layers of Silastic. Only 0.04″ thick and very flexible, the units readily pinpoint controlled heat to any desired location.

Avion simply tapes a heating unit around each accelerometer. Once installed, the two thermostatically controlled heaters — one rated at 8 watts, the other at 2 watts per square inch — maintain internal temperatures at the desired level. The larger circuit helps warm up the unit and then cuts out, leaving the 2-watt circuit to maintain the temperature at 85 C, plus or minus five degrees.

Electro-Flex specified Silastic for the insulation material because of its superior physical and dielectric properties. Vulcanized in Silastic, the heater elements are completely sealed against moisture and current leakage. The silicone rubber can repeatedly withstand temperatures as high as 260 C without loss of insulating efficiency or flexibility.

As still another measure to assure smooth uniform performance, Electro-Flex engineers specify the use of a Dow Corning silicone fluid to damp movement of the accelerometer pick-off elements. *No. 615*



FOUND: EDUCATED FLUID

You can count on silicone fluids to perform exactly the same way time and time again under extremely variable conditions! Here's how designers at Archer-Reed Company, Dearborn, Michigan, put this stability to work in their Micro-Scanner:

An ultra-sensitive instrument, the Micro-Scanner can measure surface *(Cont. Pg. 2)*

HEAT-SINK SEALANT

"Just a smidgeon" of a silicone compound is frequently all it takes to assure a new measure of reliability for delicate electronic components. Industro Transistor Corporation provides an excellent example —

Industro pots and protects the junctions of its tiny transistors with a minute quantity of a Dow Corning silicone compound. This greaselike silicone material seals out moisture, rapidly conducts heat away, and cushions the junction against shocks.

In addition, the compound prevents metal from splattering against the transistor while the cap is being welded in place. Being inert, the silicone material does not poison or contaminate the junction. Nonmelting and nongumming, Dow Corning silicone compounds maintain the same consistency from —40 to 400 F and retain their insulating efficiency through highly adverse conditions. *No. 616*

SILICONE FLUIDS *(Continued)*

roughness in increments of five ten-millionths (0.0000005) of an inch! The scanner's most unusual feature, however, is its ability to report roughness of any surface regardless of contour, as if it were flat.

Archer-Reed achieved this kind of performance by interposing a "leaf and book" floating link between a diamond-point stylus and calibrated dial. The unit is filled with high viscosity Dow Corning 200 Fluid. Any gradual up or down "leaf" movement has no effect on the "book" and therefore, does not register. On rough surfaces that cause the leaf to move rapidly, however, the viscous silicone fluid ties the leaf to the book, and the movement is transmitted to the dial.

The amount of 200 Fluid used in the Micro-Scanner is insignificant, but the device is designed around it and wouldn't work without it. A high viscosity 200 Fluid proved ideal for this application because the silicone fluid's viscosity is virtually unaffected by temperature, oxidation or breakdown under shear. A test scanner initially charged two years ago with 200 Fluid still has the same volume of liquid, and viscosity is unchanged.

OTHER FACTS about Dow Corning silicone fluids: serviceable from —100 to 400 F, they are available in many viscosities to meet specific requirements. *No. 617*

new literature and technical data on silicones

DESIGNS ON THE MOON. Created specifically to meet the informational needs of rocket and missile designers, an illustrated 8-page brochure describes the finest in silicone materials—rigid, rubbery, fluid, and dielectric. Whether you're concerned with nose cones, guidance frames, propulsion, or ground supports, your most rapid progress toward miniaturization, weight reduction, and just plain reliable performance may depend on the specification of silicone products. Explore the possibilities that Dow Corning Silicones offer. *No. 618*

ANOTHER FIRST for Dow Corning Silicones. A compilation, reprinted from Electronic Design, is now available. This designer's reference is arranged as a materials selection guide spelling out the "why" and "how" of various solutions to each of a dozen problems confronting designers of electronic equipment. This valuable, 8-page materials selection guide can be added to your files by writing for ---------- *No. 619*

SEE SILICONES IN ACTION at the IRE show March 23 through 26. If you miss the show, you can still get close to the engineering attributes of silicones as dielectrics. A 12-page booklet reviews silicone fluids, compounds, resins, varnishes, wire enamels, laminates, and other proven materials for the design of electrical and electronic equipment. *No. 620*

WHAT silicones can best meet the needs of a variety of problems involving materials ranging from resins to rubbers, dielectrics to water repellents; graphic examples showing WHERE many Dow Corning silicone products are currently being used; and information on HOW to get specific data on the Dow Corning silicone material best suited to any application are contained in the 1959 Reference Guide. This up-to-date, 16-page selector is ready for your files. *No. 621*

LESS TOIL through utilization of solventless silicone laminating resins. These Dow Corning materials offer designers a fast and economical wet lay-up method of making intricate prototypes or short production runs where expensive dies are not justified. Outlining excellent heat resistance, electrical properties and superior water repellency, a new data sheet also describes how these two glass laminating resins can be blended to meet viscosity requirements. *No. 622*

Dow Corning Corporation, Dept. 8615, Midland, Michigan

Please send me: 614 615 616 617 618 619 620 621 622

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TITLE _____

COMPANY _____

STREET _____

CITY _____ ZONE ____ STATE _____

SILICONE NEWS is published for design and development engineers by

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Dow Corning CORPORATION

MIDLAND, MICHIGAN

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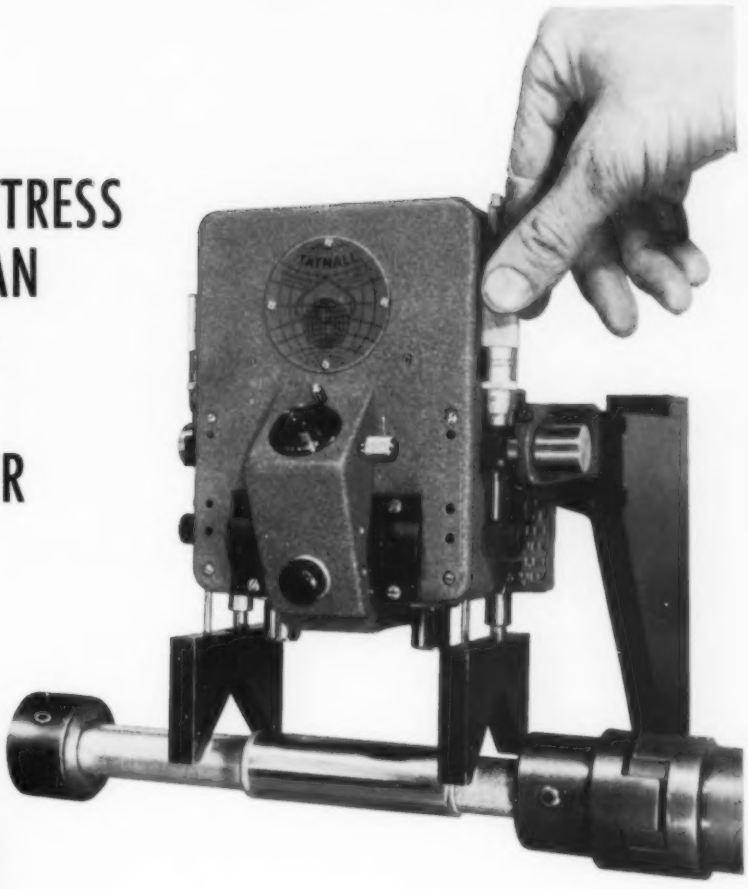
CANADA: DOW CORNING SILICONES LTD., TORONTO GREAT BRITAIN: MIDLAND SILICONES LTD., LONDON FRANCE: ST. GOBAIN, PARIS

THE PHOTOSTRESS TRANSDUCER CAN SERVE AS A SLIPRING-LESS TORQUEMETER



PhotoStress converts strain into color. The PhotoStress transducer converts color into electrical signals. Thus color patterns can be recorded accurately on oscillographs or other recorders or indicated on meters with no contact between the transducer and the part being measured.

The transducer is a servo-operated, null balance system consisting of two polarizing channels pointed at the torque shaft. A cylinder of PhotoStress plastic is bonded to the shaft, without cutting the shaft or without attaching slip rings. One channel looks at the active plastic, the other channel looks at reference plastic. The system compares the signals from the active and reference plastic, canceling out the effects of temperature and external light, photocell sensitivity, and power supply stability. The readout is digital and in millivolts for direct indication or recording. The accuracy is better than ¼% full scale, with long term stability 0.1% full scale and 1.5 microinch per inch strain accuracy. There is no speed limitation.

The same system can be used with pressure cells, load cells, extensometers, flow meters and stress analysis.

Write to Dept. P-1 for complete details.

TATNALL MEASURING SYSTEMS COMPANY

A SUBSIDIARY OF THE BUDD COMPANY • P. O. BOX 245 • PHOENIXVILLE, PENNSYLVANIA

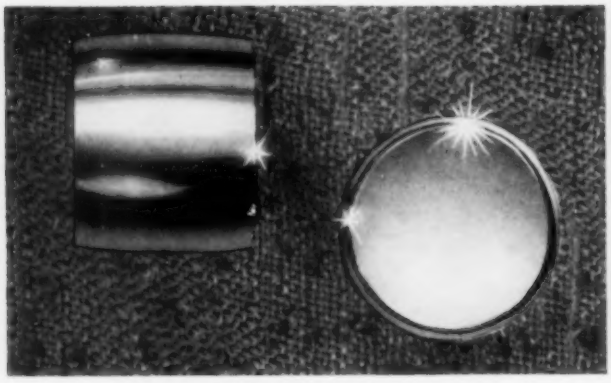
IN CANADA—TATNALL MEASURING AND NUCLEAR SYSTEMS, LTD. • 46 HOLLINGER RD. • TORONTO 16, ONT.

Budd

News! The best features of modern bearing design combined

Spherical

SELF-ALIGNING ROLLER BEARINGS BY LINK-BELT



BIG, HIGHEST-CAPACITY ROLLERS. Each bearing has a maximum number of rollers—as large as possible, yet all components are in optimum balance. Precision-ground to extreme accuracy, these convex rollers offer maximum economy for all applications.

HIGH, HEAVY INNER RACE FLANGES. Hefty inner race has sturdy shoulders which offer convenient hold for assembly and removal of bearing. They end problems of cutting away shaft or applying pressure at outer race . . . avoid any need to skimp on shaft shoulders.

BIG, mirror-smooth convex rollers *plus* heavy, broad-shouldered inner race *plus* centrifugally-cast bronze, precision-machined retainer! Only from Link-Belt do you get ALL that is best in bearing design.

Individually, these elements represent major improvements on accepted design concepts. Collectively, they constitute the most efficient spherical roller bearings available . . . promise unequalled economies, whatever the application. Men who know bearings will readily recognize new contributions to capacity, endurance and ease of maintenance.

For the good of your equipment, take time for a feature-by-feature comparison with any bearings you're now using. Your Link-Belt office will gladly explain the many performance advantages evolved with this new design. It can furnish full data on industry's most complete line of ball and roller bearings . . . pillow blocks and flanged, flanged cartridge, cartridge and take-up blocks.

LINK BELT

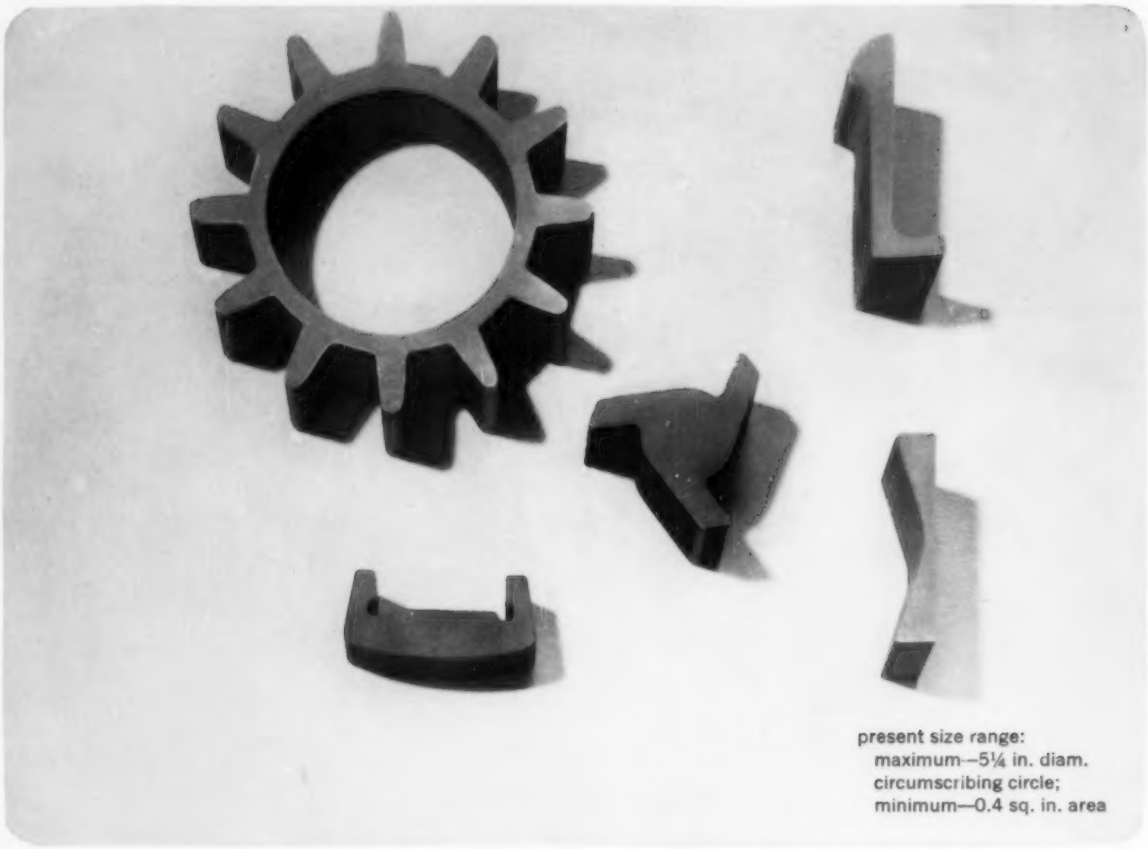
MANUFACTURER OF SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Brazil, Sao Paulo; Australia, Marrickville (Sydney), N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,610-A

and refined in

PRECISION-MACHINED, CENTRIFUGALLY-CAST BRONZE RETAINERS offer many times more support and ability to withstand high stress. They are not stampings—they space rollers accurately under extreme speeds and loads. Independent cage action for each row of rollers assures maximum bearing efficiency.

Experience**—the added alloy in **A-L Stainless, Electrical and Tool Steels



present size range:
maximum—5¼ in. diam. circumscribing circle;
minimum—0.4 sq. in. area

- 316 Stainless
- 304 Stainless
- Tool Steel Atlas 93
- SAE 4130
- 410 Stainless

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If you're hogging out sections, paying for special mill rolls on small orders, or waiting for minimum rolling mill tonnages, Allegheny Ludlum Steel Extrusions are your answer. They will save you scrap loss, slash your machining costs, hold down your inventory requirements and cut delivery time.

Extruded shapes save money on expensive materials and on costly machining. Non-ferrous applications in the last decade have proven it. Now even greater savings are possible with tough, strong metals in Allegheny Ludlum Steel Extrusions.

Intricate extruded shapes in all stainless grades, tool steels, carbon steels, electrical steels, high temperature alloys, even zirconium and nickel alloys are now in production at Allegheny Ludlum, cutting costs in many different industries.

Costs and minimum order quantities are surprisingly low. Charge for die design is under $200. Orders taken for as little as 40 pounds.

To learn more about the time and cost-cutting possibilities of Allegheny Ludlum Hot Steel Extrusions, send for the extrusion booklet—12-pages of design and engineering information with process and product explanation, material properties, design tips and limitations, tolerances, order instructions, etc. Or call any A-L office for technical assistance. ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*** Address Dept. PE-15.

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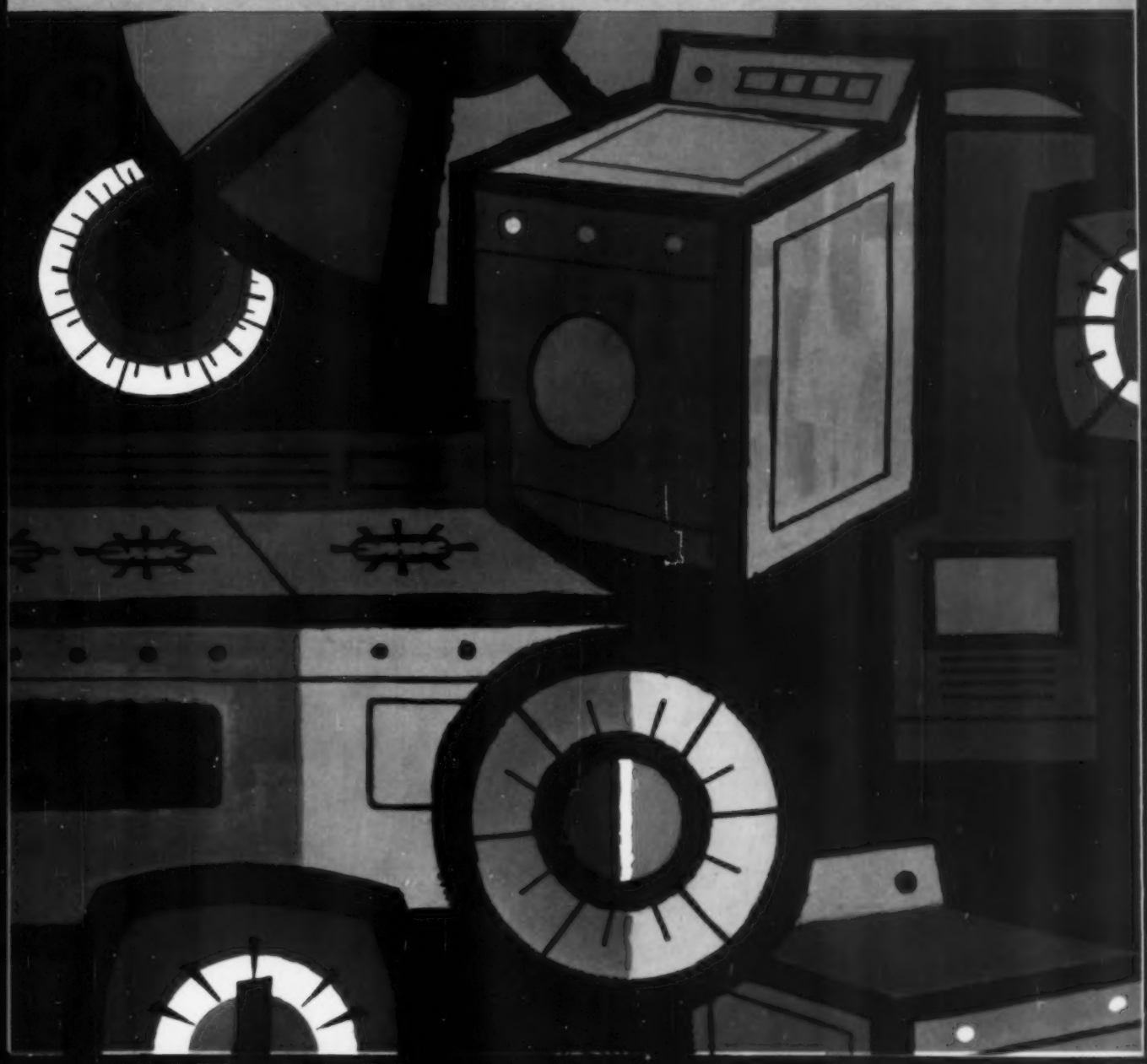
TEMPERATURE SENSORS

Here is a proved way to beat your competitors on price and performance, and improve your profits. Nothing can touch these cold and heat sensing devices for low cost, accuracy and long life!

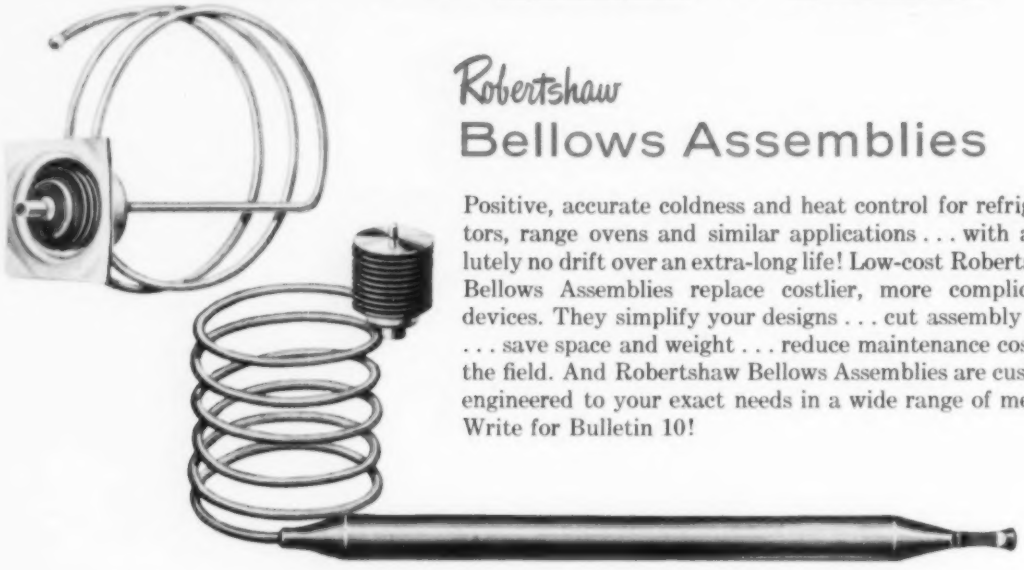
over



Robertshaw sets the pace with

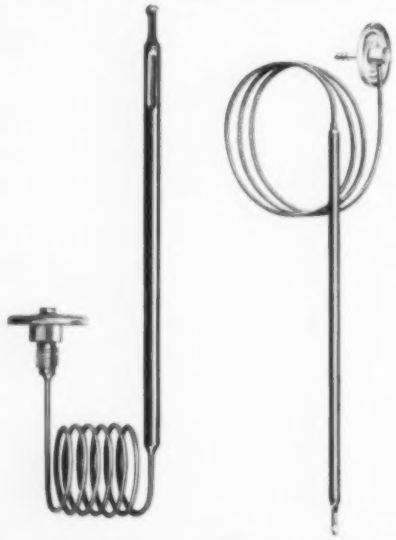
TEMPERATURE SENSORS

never before so accurate or low-cost!



Robertshaw Bellows Assemblies

Positive, accurate coldness and heat control for refrigerators, range ovens and similar applications . . . with absolutely no drift over an extra-long life! Low-cost Robertshaw Bellows Assemblies replace costlier, more complicated devices. They simplify your designs . . . cut assembly time . . . save space and weight . . . reduce maintenance costs in the field. And Robertshaw Bellows Assemblies are custom-engineered to your exact needs in a wide range of metals. Write for Bulletin 10!



Robertshaw Diastat Assemblies

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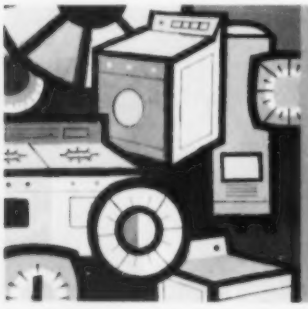


Robertshaw-Fulton CONTROLS COMPANY

BRIDGEPORT THERMOSTAT DIVISION • Milford, Connecticut

DEVELOPMENTS TO WATCH...

Lubricants for the 1800-F range . . .

. . . come a step closer as a result of a new study to develop better bearings for "space ships of the future."

Working under Boeing sponsorship, E. M. Klemgard of Washington State Institute of Technology is studying the effects of a number of high-melting-point, solid-film inorganic lubricants on a new group of nickel alloys, and has developed a new process for diffusing chlorine and fluorine compounds into the crystals as well as into the grain boundaries of high-temperature alloys. He has a special ceramic furnace, too, that makes it possible to apply high temperatures and pressures (to 30,000 psi) to parts in motion, thus "simulating conditions that would be likely to occur in a space vehicle as it cuts through the atmosphere."

Twenty cents worth of explosives can form high-alloy steels . . .

. . . titanium, and other tough, hard materials into intricate shapes, and do it on a production basis, Ryan (San Diego) engineers believe. But, though explosive forming is now gaining wide recognition, much information is still needed on which type of explosive to use, how much should be used, and where it should be placed.

To establish definite forming parameters for various metals, and to find out more about the mechanisms of high-speed deformation, Ryan is joining the group of pioneering companies (*PE—Jan 6 '58 p 56; Dec 15' 58, p 5*) which are setting up major programs in explosives research. Ryan will be working with both shaped charges and the new sheet explosives, and will test them on metal ranging in thickness from 0.016 to 0.063 in.

Standby power in milliseconds . . .

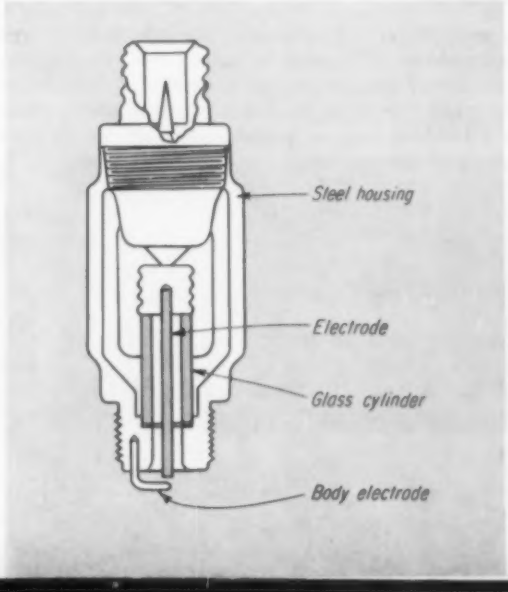
. . . is the claim of Consolidated Diesel for its new emergency generating set which "restores full voltage so quickly that the discontinuity can not be detected by a person watching an oscilloscope."

The new unit has a synchronous dynamo, a flywheel, and a magnetic clutch in addition to the diesel engine and its associated controls.

When normal line power is being supplied to an installation, Con Diesel says, "the dynamo acts both as a motor to drive the flywheel and as a synchronous condenser. . . . But, should the power fail, the dynamo immediately becomes a generator, driven by the inertia of the flywheel. Then the magnetic clutch closes, and the inertia of the flywheel is applied in starting the engine." Since the inertia of the flywheel supplies power for the instant (approximately one sec) required by the engine to take over the full load, the only discontinuity involved is the time required for the voltage regulator to act. This, says Con Diesel, is 1.5 millisec.

Spark plugs made of glass and insulated by gas . . .

. . . are claimed by their Hungarian developer to be cheaper, easier to adjust than standard ceramic units. It's also claimed that they produce a stronger spark, can be used with high-compression engine, and permit unusual compact design. Furthermore, the Hungarians say, use of a thin cylindrical-glass insulating body reduces thermal stress and permits direct observation of the combustion process.



Gas-insulated, glass-bodied electrode is diagrammed here. Hungarians think it represents a major improvement.

DEVELOPMENTS TO WATCH...

Improved lube oils and greases . . .

. . . and more effective pickling agents and plating solutions are forecast by General Mills' Chemical Div as it launches a new series of fatty nitrogen chemicals.

One new group of compounds, for instance, is said to have "very high lubricity," stability over a wide temperature range (−65 to over 500 F), and a high viscosity index; also to be "completely miscible" with most petroleum fractions, yet insoluble and non-dispersible in water. These are trialkyl tertiary amines, to be marketed by General Mills under the trade name Alamines.

Another new group, the Deriphats (amphoteric surfactants) combine detergency with corrosion inhibition, and are said to "retain their very excellent surface activity and wetting properties in the presence of strong mineral acids." GM researchers foresee their use in electroplating and pickling solutions, as well as in such specialized applications as oil-well drilling compounds.

Stronger epoxy adhesives at lower cost . . .

. . . are forecast by Monsanto Chemical Co. An epoxy resin modifier is the key. Monsanto says its Mod-Epox, when added to liquid epoxy resin systems, boosts bond strength 40 to 80%, and may make it possible to substitute lower cost adhesives for those presently used. Furthermore, it is claimed, the modifier speeds curing and improves durability of the resins to which it is added. Greatest improvement in adhesive strength (80%) was shown in glass-to-glass bonds, with an average of 50% being obtained on steel-to-steel. The 40% increase was reported for aluminum-to-aluminum bonds.

Hydrocarbon fuel cells for direct conversion of petroleum . . .

. . . into electrical energy are being studied by several oil company laboratories. These are similar in concept to the hydrogen-oxygen cells in which oxidation of the fuel gas causes a current to flow from one electrode to the other (*PE—Sep 23 '57, p 8; Feb 17 '58, p 18; Nov 3 '58, p 10*); but these would use relatively inexpensive petroleum-derived gases instead of costly hydrogen—holding out the hope of far lower operating costs.

Theoretically such cells can achieve efficiencies as high as 80%, and there is almost no limit to the size in which they can be built. Full-scale power plants are already being envisioned.

However, as Esso Research & Engineering points out, many fundamental questions in regard to hydrocarbon fuel cells are still unanswered; and most cells built so far supply only enough power to light up a small lamp. Right now, therefore, the emphasis is on basic research and on instrumentation that will supply some of the missing answers.

Progress in developing titanium alloys . . .

. . . for applications requiring high strength and corrosion resistance is reported by several research groups; but there is discouraging news as well.

On the credit side is an Air Force report which describes a Ti-Al-Mo alloy as "promising" for jet engine conveyor blades, says it is relatively easy to fabricate, and has an endurance limit at room temperature some 5000 psi higher than Ti-6-Al-4-V. (This report, PB 131 798, may be obtained from Office of Technical Services, Washington 25, DC for $1.25.)

Also on the credit side is a Bureau of Mines study of chemical and galvanic corrosion resistance. Tests of commercially pure titanium, and Ti-Mn, Ti-Al-Sn, Ti-Al, and Ti-Cu alloys showed all had good corrosion resistance at room temperature, and superior resistance in many environments. Alloying does not seem to have an adverse effect in this respect. A limited number of copies of this Report of Investigations (5423) is being made available through the Bureau of Mines Publications Distribution Section, 4800 Forbes St, Pittsburgh 13.

On the debit side, researchers at Illinois Institute of Technology report little success in finding a weldable sheet alloy of high strength that does not require post-welding heat treatment.

Also on the debit side is a report (prepared for Wright Air Development Center by Massachusetts Institute of Technology) which indicates that, while titanium-aluminum oxide extrusions can be produced, they are far too brittle for practical use. Addition of rare earth oxides does not seem to help very much. —ARG

Switch to Printed Circuit in Missile Saves Weight, Production Time

DETROIT—A proposed printed-circuit approach to the Redstone missile's main distributor in the electrical system will reduce the weight from 32.2 to 13 lb and reduce the space required by 79% (see below). At the same time, the new design retains all original mountings and external connections to avoid disrupting other systems, or generating a chain of related modification in the production line. Both the old and new units must handle about 200 separate circuits.

The present system is regarded as reliable as missiles go—the Redstone has a record of 35 completely successful firings out of 39 attempts. However, according to Chrysler's Jonah Wittenberg, managing engineer of guidance and control ground equipment and missile design: "The present distributor is too big, too heavy, and takes too many man-hours to make. This is true of the distributor in the Jupiter missile, which we also build."

Wittenberg estimates that on an assembly line basis, the printed-circuit distributor would require 100 man-hours to produce, compared to 360 for the present unit. Reducing number of hand-soldered connections from 1500 to 110 saved much time.

The need to retain conventional connectors, where the male pins are all of the same height, proved troublesome, because connector-pin spacing was insufficient for soldering "lands" where terminated on printed-circuit board. Solution was three tiers of printed-circuit board, using female connecting pins of varying lengths.

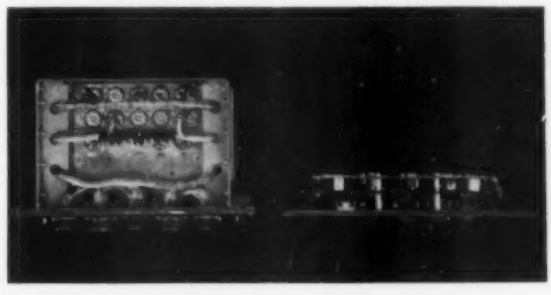
There are two master boards. The lower one contains the basic interwiring. A number of intermediate levels augment the area of the lower board where 40-pin connectors are used. All circuits in these and the lower board are connected to the upper board by eight printed-circuit connectors, four at each of the two narrow ends of the distributor.

The inner side of the upper board contains all functional components. The original wired unit used about 30 6-pole relays. Many of these poles were wasted, so it was possible to substitute 35 miniaturized 2-pole relays and retain only two of the larger ones. A bonus from confining functional components to the upper board is that a malfunction can be corrected by merely replacing this board, rather than the whole distributor.

Wittenberg says production technique for the printed board is normal, despite the large number of circuits. The glass-reinforced epoxy material is available, and once masters are designed, Chrysler can produce a prototype circuit board in a day.

Plans for using the new design in future production blocks of Redstone and Jupiter have not been finalized, but the development has passed vibrational and environmental checks. Wittenberg feels that if printed circuitry can be designed into a new missile at its concept, size and weight could be still further reduced. Developments in printed wiring cables will result in designs that eliminate bulky connectors and wire cables, and permit transistor-switching circuits.

The large and small of it . . . shows reduction in size of the Redstone electrical distribution unit when printed circuits are used. The new printed circuit unit has not yet been incorporated into the production line of the missile.



Miniature Loudspeaker Solves Speech Problem

CLEVELAND—A private PA system, developed for persons forced to use esophageal speech as a result of surgical removal of the larynx, will allow the voice to "carry" even though the user must speak in whispers. Major difficulty with esophageal speech is that it is physically tiring. Speaking above surrounding noise adds to the hardship.

Design problems confronting Rand Development Corp, Cleveland, included: eliminating feedback, getting one watt of power from a small package, getting long battery life. The microphone must be held close to the mouth in order to speak into a small (⅛-in. dia) hole in the face plate of the microphone. Using four transistors with mercury batteries, the speech amplifier draws only 2-4 milliamps on standby — more with speech. The speaker used is like that in some small transistorized radios. The case in the wearer's pocket (above) measures 4 x 2½ x 1 inch. Volume is adjustable.

This device is not to be confused with the Cooper-Rand Speech Aid de-

scribed in *PE*—Mar 3 '58, p 21. The Speech Aid supplies tones to the mouth to replace those generated by the vocal chords. The user then "shapes" these tones into intelligible speech by normal lip and tongue movements. The latest device is used by people who are in the process of developing esophageal speech, or who are put on "voice rest" from time to time. Actually, it can be used by anyone needing a small, lightweight, portable amplifying system.

GM Clears the Air, Only One Small Car

DETROIT—Contrary to reports otherwise, General Motors will offer only one small car in 1960—the oft-described model with the 120 cu-in. aluminum air-cooled engine mounted in the rear. However, it very likely will be sold by other GM dealers besides Chevrolet.

Ford may go a little further and offer a face-lifted version of its small car for marketing by its chain of M-E-L dealers. Fundamentally, the cars will be identical, offering a slightly canted, cast-iron overhead valve 6-cylinder engine in the orthodox front position. The second car, if it materializes, may be called the Edsel to bolster the market coverage and prestige of that make. If sales of standard-size Edsels do not pick up, there is a possibility of a third compact type of car using the small car body on a slightly longer wheelbase. However, Edsel will be given another year or two to prove itself.

CHRYSLER SPEEDS TOOLING

Chrysler's entry, now being tooled on a crash basis, will be along by the end of the year. It, too, is orthodox. Tooling bids have been asked to cover either aluminum or cast-iron engines. This 6-cylinder, overhead valve engine will also be used in standard-sized Plymouths.

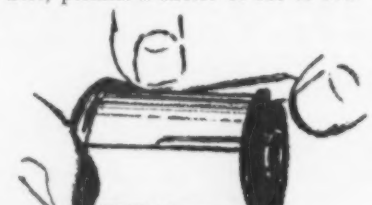
All the small cars will offer optional automatic transmissions. Other expense-building extras, though, will be minimized. Thinking here can be illustrated by an example: Optional electric window-lifts require a thick, costly door structure whether used or not.

You can spray chopped and/or continuous rovings . . . with the above fibre-resin spray depositor. In drawing below, cutter wheel with injector-type blade being removed is redesigned to permit spraying continuous long strands.

New Plastic Gun Can Spray Chopped or Continuous Fiberglass Rovings

CLEVELAND—A new design of a glass fiber-resin depositor spray gun will permit chopped rovings to be sprayed on while continuous long strands are sprayed through the same mechanism (see action photo above). These long strands are completely wetted down as they hit the surface and are hand-rolled flat when an even amount is built up.

A special switch on the gun, designed by Rand Development Corp, here, permits a choice of cut or continuous roving, or a combination of the two. Big advantage to the addition of the continuous long strand is a higher tear resistance to the spray-molded part.



At the time of the initial announcement of the gun last year, (*PE*—Jan 13, '58 p 17), the gun was capable of making fiberglass parts of 30-40% glass content, spraying 3 lb of plastic laminate per minute. Improvements in the gun have boosted these figures to a 50% glass content at a spray rate of 4 lb of plastic laminate per minute, or a 6-lb plastic laminate spray rate at a 33% glass content.

Major potential for sprayed reinforced plastic has been for boats. About 4000 fiberglass boats were made by this process last year, and Rand estimates that this figure will be boosted to about 20,000 this year.

However, other applications include missile nose cones for the Picatinny Arsenal. The nose cones are made by spraying on a wood mandrel the shape of a nose cone. Still other uses beyond the development stage are: truck fenders; belt and chain guards; cabs for cranes; and material handling containers.

Most Aircraft-missile Engineers Engaged in R & D

WASHINGTON—The US aircraft and missile industry employs more scientists and engineers for R & D than any other major manufacturing industry, according to a survey conducted by the National Science Foundation which reveals the aircraft and parts industry employs about 67% of its total force of 84,900 scientists and engineers in research and development projects.

Foresee More Stainless Honeycomb with New Furnaceless Brazing

CHULA VISTA, CALIF — Removal of many engineering and economic limitations to the use of stainless-steel honeycomb sandwich structures is predicted in view of newly developed, flexible electric-heating blankets to raise the raw sandwich to brazing temperature. Developed jointly by Rohr Aircraft Corp and Electrofilm Inc of Van Nuys, the method eliminates the need for huge brazing furnaces for many fabrication jobs and according to Hugh Rush, laboratory manager for Rohr, "lends itself to more complex configurations and introduces a whole new tooling philosophy for honeycomb fabrication."

Rohr has played a major part in developing the furnaceless brazing concept, is currently conducting final evaluation tests with sample structures. "Next," Rush says, "we will run 4-ft-square sections, both flat and wedge-shaped. Even though it is part of our final test phase, this is approaching production parts in size. Actually, some parts we make for aircraft now are no larger.

"Within two months," he continues, "we expect to be in production on a limited basis. Right now, it looks as though we should be able to make brazed honeycomb structures that will be competitively priced with adhesive-bonded structures within three years."

Rush said he does not offer the new system as a final answer to all brazing problems: "There's no one best way' to do all jobs. The more tools we have, the better equipped we are to handle each one in the most suitable manner."

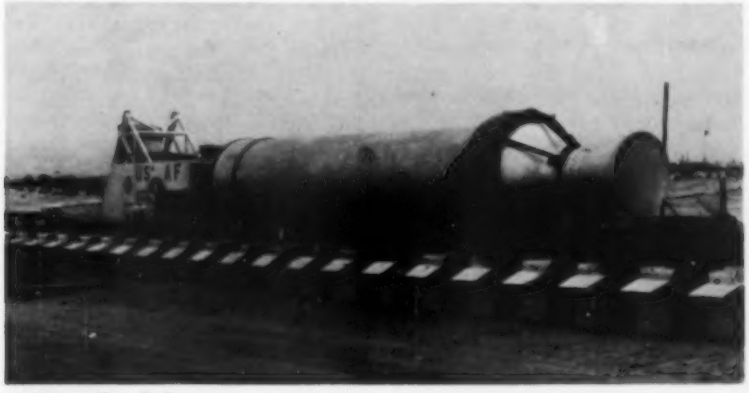
Skip Haag, laboratory superintendent, reports that Rohr became interested in the subject with the realization that additional brazing furnaces would soon be needed to keep up with the growing demand. Prices start at $30,000 "for a very small one" and can go as high as $250,000 for a large, completely instrumented unit. Even Rohr's biggest furnace, a 6 x 12-ft panel produced last year, is taxed to the limit. "In a furnace," Haag says, "you can't watch what you're doing. It's hard to control because you have to heat or cool anywhere from 30 to 60 tons; so you use an expensive, highly complex system of instrumentation."

In conventional honeycomb brazing, a sandwich is made of the outer steel skins, layers of silver brazing compound, and the honeycomb. Because the silver alloy is extremely sensitive to oxidation, the whole sandwich is welded into a steel container filled with inert argon gas, and partially exhausted during the brazing cycle. The furnace must be gradually raised from about 600 F to 1800 F, held, then reduced to 600 F again. An additional cycle back to 1000 F may be needed to age the steel for maximum strength. A 10 x 10-ft furnace may take as much as 15 million btu's to reach 1800 F, added at the rate of a million Btu's per hour for 15 hr. As the parts themselves weigh only a few hundred pounds, Rush reasoned that about 150,000 Btu's in the right place should do the job, and he approached Electrofilm to determine whether its wire-mesh heater could be adapted for brazing.

Result is a high-temperature wire-mesh heataer in a blanket of high-temperature silica insulation. This is placed directly next to the outer skin of the steel container and the complete unit blanketed all around with additional high-temperature insulating pads. After some experimentation to determine and control heat input, structures were obtained that compare favorably with the best made by furnace brazing. "Up to now, we have been most interested in developing the blanket as a heat source," Rush says. "Now we can start to look at applications, since we feel that reliability, controllability and life of the blankets are well under control. This flexible heat source gives us completely new tooling concepts for brazing."

Elimination of core welding is one of the future aims, Rush adds. "Right now, if you poke a hole in a honeycomb section, it is impractical to repair it in the field. We believe our system will give us a way to braze-in a new section and then heat-treat the entire repaired area. We're investigating other heat-treating applications, and other jobs where a flexible, high-temperature heat source can be used to good advantage." Blankets currently undergoing tests have withstood 50 cycles; a 100-cycle life is considered a reasonable target.

Better brazing, particularly of irregular shapes and thin edges which tend to distort in a furnace, is anticipated as a result of better control of the



100,000 lb of thrust . . .

is delivered for 10 sec by this Phillips Petroleum-Astrodyne built, solid-propellant rocket motor along a 35,000-ft Holloman AFB test track. "Megaboom" hurtles a 2000-lb payload at speeds of more than 1200 mph. Measuring approximately 38 in. dia and 22 ft long, the motor weighs 9460 lb; body is a steel cylinder closed on the forward end, with a fixed straight nozzle at the rear. Propellant is a modular design with a series of ammonium nitrate extruded segments suspended on longitudinal steel rods and supported within the rocket case by perforated steel plates. The modular design propellant makes possible sled rocket motors ranging in thrust from 6,500 to 300,000 lb and in duration from 3.5 to 15 sec. The F-100 aircraft is zero-launched with a 4-sec, 130,000-lb thrust unit. The modular design offers a new technique for programming sled runs where the "G" rate is the main criterion. In test sled programs, the motor cases can be reloaded and fired up to five times.

application of heat. In addition, the new system is expected to require considerably less power to do the same job, and is much more economical of floor space. Where a 6 x 12-ft area furnace requires 12 x 25 ft of floor space plus another 12 x 20 ft for the loading car's tracks, the blanket brazing system requires only one or two feet on each side of the section actually being heated. In high-production use, blankets could be stacked.

Describe 'Handy-man' Satellite

Los Angeles—A "handy-man" satellite to relay radio and television waves around the world, help mariners chart their courses, and perform other odd jobs was described to a group of engineers here last week.

Detailed in a paper presented at the Aviation Conference of the American Society of Mechanical Engineers, the proposed space outpost consists of a plastic sphere to be hurtled 1000 miles into space. It will be covered with a thin film of vapor-deposited aluminum to make it visible on earth, provide a good reflecting surface, and protect it from long-term exposure to the sun. When it reaches its proper height, a one-pound container of gas will inflate the folded plastic sphere for its orbital journey.

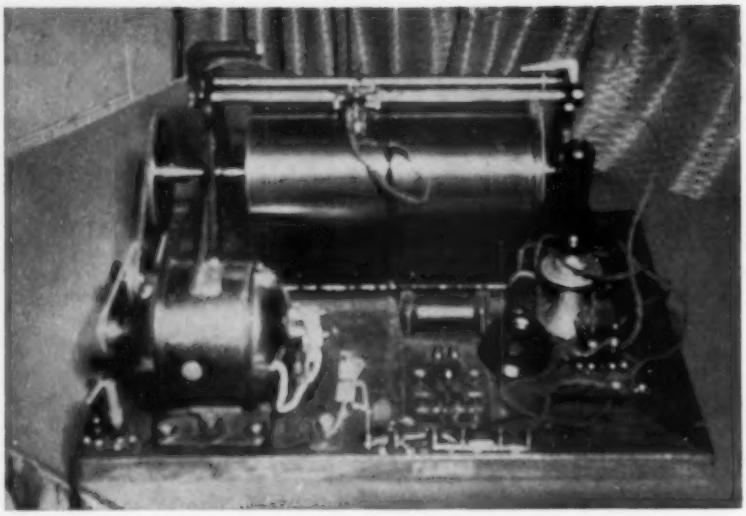
According to the authors of a paper describing the satellite, George P. Wood and Arlen F. Carter, aeronautical research engineers at the NASA Langley Research Center in Virginia, the prototype will be 100 ft wide with a total weight of about 100 lb. The type of plastic specified must be able to stand such extremes of temperature as direct exposure to hot rays of the sun or the cold of complete shadow.

Call Them Junior

Montreal—Professional engineers in the province of Quebec will be required to add the word "Junior" to their title for a period of two years from start of practice.

The new regulation was adopted by the Province Legislative Assembly at the request of Quebec's 8000-member Corporation of Professional Engineers.

The bill removes the title of "civil" engineer which was given to all graduate eqngineers and replaces it by the word "professional" engineer.



First Wire Recorder Still Works

Los Angeles—The oldest wire recorder in the world was shown here at the Audio Engineering Society's Show and 6th Annual Western Convention. Now 60 years old, the recorder (above) still works, playing a recording made by Kaiser Franz Joseph at the World Exhibition in Paris in 1900.

Its inventor, Valdemar Poulsen, sometimes referred to as the "Danish Edison," was born in Denmark in 1869. He contributed to the world of science two major inventions—the Telegraphone and the arc-generator. The former was conceived in 1898. Its best known latterday application is the tape recorder for home and office use and, more recently, for recording television programs.

The first magnetic recording came after Poulsen swept a permanent magnet over an iron plate, then dropped iron dust on the plate. Dust gathered on the iron plate in the pattern previously made with the magnet. This led him to experiment with the simplest magnetic recorder. He suspended a yard of piano wire on a piece of wood and along this wire guided a small electromagnet connected to a microphone. While doing this, he talked into the microphone. When he next connected a receiver to the electromagnet and repeated the stroke along the wire he heard clearly his voice played back.

This began several years of experiments in the development of telegraphones. Although the quality of Poulsen's telegraphones was considered superior to the phonograph, only a few were made because of the high price. They were manufactured in the US by The American Telegraphone Company and The Telegraphone Corp. Exhibited world-wide, the Telegraphone won Poulsen the Grand Prix in Paris in 1900.

Before his death in 1942, he experienced a fast-rising interest for his invention. During the second world war a major break-through for magnetic recording became possible through Braunmuhl and Weber's discovery that the application of a high-frequency signal superimposed on the signal to be recorded resulted in a quality and fidelity never achieved with the original telegraphone.

USSR Announces Gas Turbine Locomotive

Moscow—A gas turbine engine for locomotives has been undergoing intensive testing and may be ready for commercial use before 1960 here.

The main shaft rotates at 8000 rpm. Speed of locomotive is expected to reach 100 mph (this figure was given without mention of load). It's said the gas turbine locomotive will be twice as powerful as conventional locomotives of the same weight. It will use mazut (a Russian residue of petroleum) as fuel. No other details were disclosed.

Slate Soviet-designed Cars for West German Market

BONN—A newly signed protocol to a Soviet-German trade agreement has paved the way for 900 Soviet cars valued at $1.07 million and $375 thousand worth of spare parts to the German market. These cars will probably be purchased largely by German companies that send salesmen to the Eastern block or firms that want to compare performance with Western products.

Of the four cars produced by the Soviets, the Moskvich is expected to stir greatest interest. A modified version of the Opel Kadett, it is 13 ft long, 5 ft wide and includes either a 1200-cc 4-stroke 35-hp engine or a 1358-cc 45-hp engine. It has dry plate clutch, shock absorbers and gets up to 33 mi per gal. Its $1200 price tag includes import duty and extras such as chromium trim and seat covers.

The larger Volgam is powered with a 2445-cc, 4-stroke 4-cyl 80-hp engine and was equipped with an automatic clutch last year. The 19-ft long Zil has a 5980-cc 200-hp V-8 engine and comes with automatic transmission, power steering and brakes. The fourth model—the Tschaika—has a 4890-cc 180-hp engine.

All cars are heavy, compared with Western models, have high ground clearance and solid durable bodies and engines. These cars are exported to 38 countries, primarily behind the Iron Curtain but also including Sweden, Norway, Greece, Iceland and Argentina.

The trade agreement between the Soviets and West Germany was signed in the spring of 1958 and calls for trade in both directions amounting to $200 million in 1958, $250 million in 1959 and $300 million in 1960. So far these trade targets have not been met.

In Germany, the Soviets have been chiefly interested in obtaining machinery and equipment for ore mining and metallurgical plants, heavy machinery, automatic transfer rolling mills, machine tools, rolled iron and steel products, and chemicals and electric appliances.

Ready Tracking Range for X-15

SANTA ANA, CALIF.—A space range, or chain radar instrumentation system for testing the X-15 will provide a continuous flow of answers to questions pertaining to pilot safety and condition of the aircraft once it has been launched from a B-52 bomber. The X-15 will fly at an altitude of 100 miles and a speed of 3600 mph.

Master control station for the $2-million new high range which extends across 400 mi of California and Nevada dry lakes, is located at NASA High Speed Flight Station, Edwards AFB. Two "up-range" stations are located in Nevada, and were built by the Electronic Engineering Co of California of Santa Ana.

Incorporated in the system is a specially designed radar-data recording system which automatically converts radar information into suitable form for the Air Force Flight Test Center automatic data-processing system. Data from the test range can be processed in 30 hours, using two operators. Formerly, Electronic Engineering says, such a procedure using photo panel methods and manual data reduction required 30 days.

Emergency landing . . . on Mud Lake, in background, above, is one of several provided for the X-15. Aerial view here shows the Beatty, Nev, tracking station, midpoint of the range.

COMING EVENTS

MARCH

16-20 . . . . American Society for Metals, 11th Western Metals Exposition and Congress, Pan-American Auditorium and Ambassador Hotel, Los Angeles.

16-18 . . . . Society of Automotive Engineers, National Passenger Car, Body, and Materials Meeting, The Sheraton-Cadillac, Detroit.

16-20 . . . . National Association of Corrosion Engineers, 15th Annual Conference and Corrosion Show, Hotel Sherman, Chicago.

23-26 . . . . Institute of Radio Engineers, 1959 National Convention and Radio Engineering Show, Waldorf-Astoria and Coliseum, New York.

23-25 . . . . American Rocket Society, Flight Testing Conference, Daytona Plaza and Princess Issena Hotels, Daytona Beach, Fla.

26-27 . . . . Society of the Plastics Industry, 16th Pacific Coast Section Conference, Hotel Del Coronado, Coronado, Calif.

31-April 2 . . . . 21st Annual Power Conference, Hotel Sherman, Chicago.

31-April 3 . . . . Society of Automotive Engineers, National Aeronautic Meeting, Aeronautic Production Forum and Aircraft Engineering Display, Hotel Commodore, New York.

APRIL

5-10 . . . . Engineers Joint Council (coordinator), 1959 Nuclear Congress, Public Auditorium, Cleveland.

7-10 . . . . American Welding Society, 40th Annual Convention and Welding Show, Sherman Hotel and International Amphitheater, Chicago.

13-15 . . . . American Society of Mechanical Engineers, Hydraulic Conference, Univ of Mich, Ann Arbor, Mich.

13-17 . . . . American Foundrymen's Society, 63rd Casting Congress and Engineered Castings Show, Sherman Hotel, Chicago.

14-15 . . . . American Institute of Electrical Engineers, Materials Handling Conference, Pfister Hotel, Chicago.

MAY

25-28 . . . . American Society of Mechanical Engineers, Design Engineering Conference, Convention Hall, Philadelphia.

25-28 . . . . Clapp & Poliak Inc, Design Engineering Show, Convention Hall, Philadelphia.

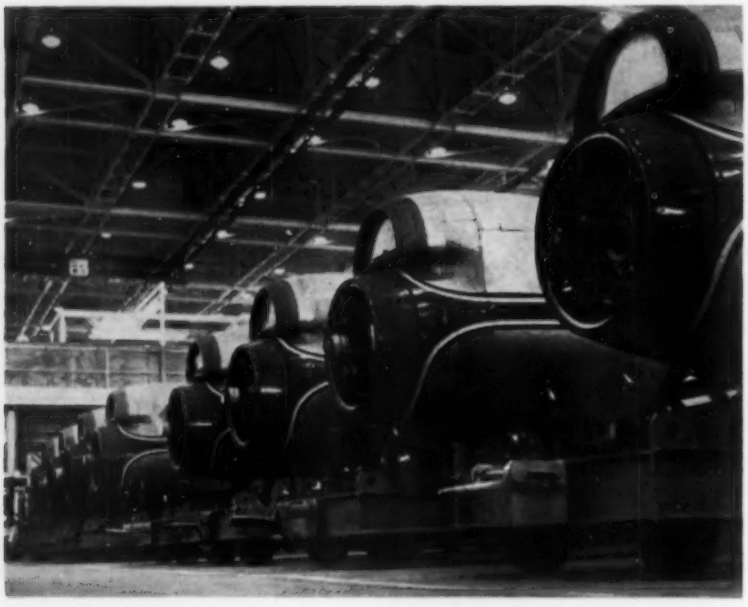
Air Force Designing Container to Send 150-lb Payload on Roundtrip Space Flight

RANDOLPH AFB, TEX—Biophysicists in the Dept of Physiology and Biophysics of the School of Aviation Medicine here are working on the design and cooling system for the container that will carry a relatively large animal into space—and hopefully back again. Up to now the department has worked on the requirements of a 15-lb payload carrying mice and a 50 to 60-lb payload with a rhesus monkey.

Next step is a 100 to 150-lb payload, possibly including a chimpanzee as passenger. One problem for such a cargo is a method for cooling the interior of the capsule if heat from the outside raises inside temperatures above predetermined limits. As now envisioned, this heat will be removed by vaporization.

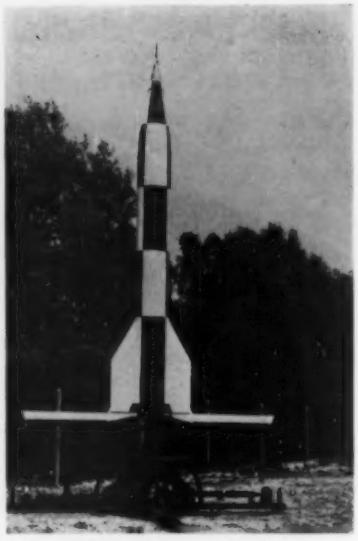
The payload will be housed in a double-walled steel drum. Between walls of the drum working from the outside in, there will be an airspace, a sintered bronze cylinder, a layer of glass wick and water. The glass wool wick serves as a water reservoir and the bronze partition as an evaporating surface. Valves controlled by an electronic mechanism inside the capsule will bleed off the water vapor.

The bio-pack inside the steel drum will house the animal and its battery of equipment. The animal will be strapped to a reclining seat constructed largely of magnesium and will ride face down on the trip out and face up on return. Equipment will depend upon size of the animal but will very likely include: a feeder, a psycho-motor or lever that the animal is trained to operate on signal, an oxygen regulator, oxygen supply bottle and carbon dioxide cannister containing material to reduce carbon dioxide to oxygen, camera, microphone, telemetering and electrocardiography equipment, recorder and power transmitter.



Allison Engineland . . .

Eight Allison Model 501-D13 turbine engines await installation on new Lockheed prop-jet Electra transports at Lockeed's California Div in Burbank. Positioned adjacent to the Electra final assembly line, the 3750-hp constant-speed engines with matching 13½-ft propellers are installed shortly before airliners roll out. Intake atop nacelle directs air to 14-stage axial flow compressor, where it is mixed with fuel and ignited. Resultant power is absorbed by 4-stage turbine in rear and transmitted through reduction gear to propeller. Turning at a constant speed of 13,820 rpm the engine provides a propeller speed of 1020 for all flight regimes. In ground operation, the ratios are reduced to 10,000 and 740 rpm; 1750-lb engine delivers 2.14 hp per pound at takeoff.



France's Veronique rocket.

French to Launch Rockets for High-altitude Data

PARIS—France will launch a series of 50 rockets during the next 12 months to obtain high-altitude data. Its Veronique above and Monica rockets will be used.

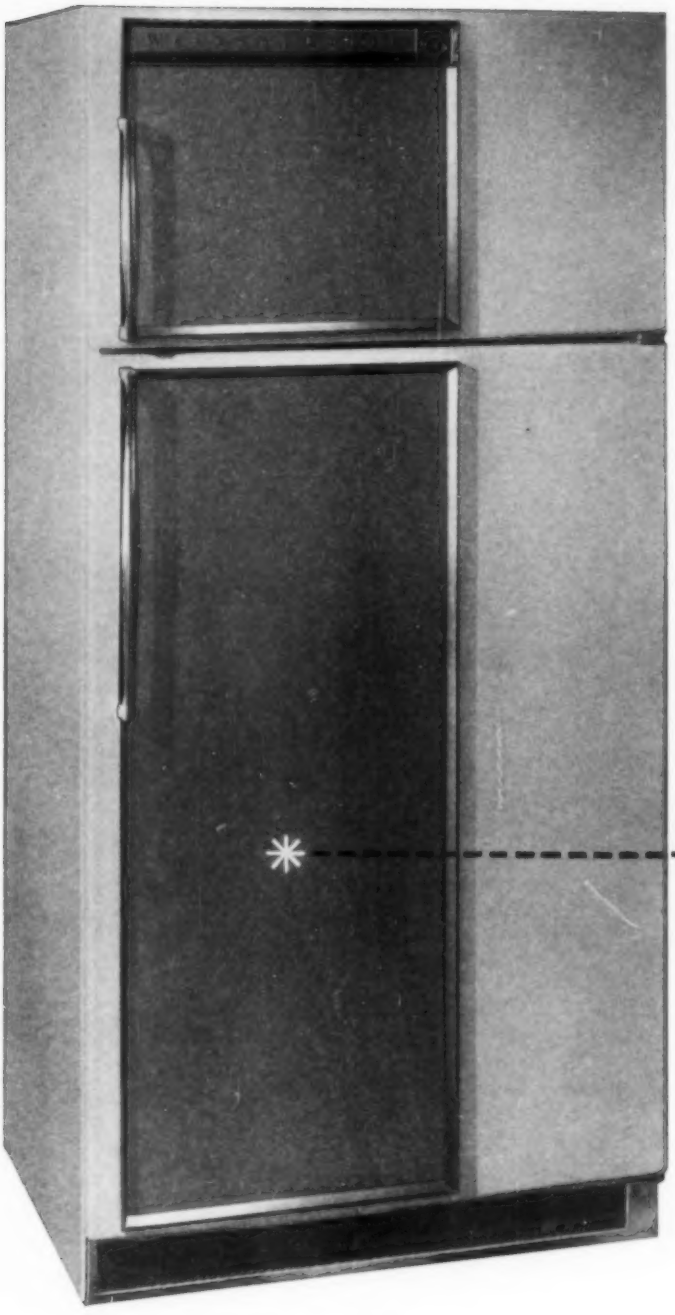
In the first phase of the experiments, Veronique rockets will probe the atmosphere at heights ranging from 31 to 150 miles. Nose cones of the rockets will carry sodium-vapor which will be ejected at selected altitudes to form a sort of artificial comet.

The French expect that the comets will ionize and become luminescent under the action of the sun's ultraviolet rays. They hope to get new data on chemical composition and air currents at high altitudes from spectrographic and other measurements on the comets.

Heat Tests Scheduled for Space Flight Program

WASHINGTON—The National Aeronautic & Space Agency this summer will make heat tests of its manned space flight program, Mercury. An Atlas ICBM will fire heat-shielding material up some 100 miles, then parachute it back to earth.

Early next year, the first of the four test phases will be started, using a cluster of Sergeant and new Thiokol rockets to test the 2000-lb capsule that will eventually carry man into space.



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Color micrograph of heat tinted section of ferritic Malleable iron showing random dispersion of temper carbon nodules in ferrite. 625X magnification.

Usability is Malleable

In the growing world of metals, certain requirements remain basic: strength . . . versatility . . . economy. Malleable iron castings uniquely answer all three. Malleable castings provide more strength per dollar than any other metal . . . are the most machinable of all ferrous metals of similar hardness.

From the great range of Malleable irons now produced in modern Malleable foundries, you can select exactly the right metal to fill your most demanding needs for endurance, resistance to impact and wear, ductility and constant uniformity. No other metal offers you so much at so low a cost.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER
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If you wish, you may inquire direct to the Malleable Castings Council, 1800 Union Commerce Building, Cleveland 14, Ohio, for information.

These companies are members of the

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ILLINOIS
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Chicago Malleable Castings Co., Chicago 43
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MASSACHUSETTS
Belcher Malleable Iron Co., Easton

MICHIGAN
Albion Malleable Iron Co., Albion
Auto Specialties Mfg. Co., Saint Joseph
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MINNESOTA
Northern Malleable Iron Co., St. Paul 6

NEW HAMPSHIRE
Laconia Malleable Iron Co., Laconia

NEW JERSEY
Meeker Foundry Company, Newark 4

NEW YORK
Acme Steel & Mall. Iron Works, Buffalo 7
Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
Maumee Malleable Castings Co., Toledo 5
National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
Buck Iron Company, Inc., Philadelphia 22
Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

TEXAS
Texas Foundries, Inc., Lufkin

WEST VIRGINIA
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46

How to Select the Best Metal to Perform a Given Set of Functions

Any equipment part can be described, at least approximately, in terms of the functions it must perform. That is, it must provide a certain strength plus resistance to wear, fatigue, impact or corrosion. The finished part must provide the best combination of all necessary factors at the lowest possible cost — a cost that must include machining, finishing and assembly where applicable.

Unique Production Method Combines Desirable Characteristics

The amount and form of carbon in ferrous metals is of prime importance. The carbon content of Malleable iron (2.00 to 2.60%) provides good fluidity at the pouring stage. Yet neither flake graphite nor combined carbon is present in finished standard Malleable iron.

As the photomicrograph of standard Malleable iron shows, the carbon has been transformed into temper carbon nodules in a matrix of ferrite during the heat-treatment given *all* Malleable iron castings. The result is a metal with a unique combination of high strength, toughness and machinability.

Pearlitic Malleable irons differ from standard, or ferritic, Malleable only in that a controlled amount of the carbon is combined with the iron to form a pearlitic matrix around the temper carbon nodules. This increases strength, hardness, wear resistance and modulus of elasticity, while retaining good ductility and machinability.

TENSILE PROPERTIES — A.S.T.M. MINIMUM SPECIFICATIONS

Standard and Pearlitic Malleable Irons				
Designation	Tensile Strength p. s. i.	Yield Strength p. s. i.	Elongation % in 2 in.	Ratio of Tensile to Yield %
Standard				
35018	53,000	35,000	18	66
32510	50,000	32,500	10	65
Pearlitic				
45010	65,000	45,000	10	69
45007	68,000	45,000	7	66
48004	70,000	48,000	4	69
50007	75,000	50,000	7	67
53004	80,000	53,000	4	66
60003	80,000	60,000	3	75
80002	100,000	80,000	2	80

Strengths up to 135,000 p.s.i. tensile and 110,000 p.s.i. yield are produced commercially under individual producers' specifications.

TYPICAL BRINELL HARDNESS NO. RANGES

Pearlitic Malleable Irons							
Designation	45010	45007	48004	50007	53004	60003	80002
B. H. N.	163-207	163-217	163-228	179-228	197-241	197-255	241-269

New Savings Result

From the wide range of properties obtainable, a Malleable iron may be selected that will most completely meet ideal design and functional requirements. Because of the great latitude of producible sizes, from a fraction of an ounce to hundreds of pounds, Malleable can be used for a wealth of applications.

Malleable iron's economy is derived in two ways. First, the casting process is generally accepted as the most economical method of producing a finished part. Secondly, being the most machinable of all ferrous metals of similar hardness, cast or otherwise, Malleable iron castings provide exceptional economies in time, tool and power consumption.

Today's Malleable iron castings offer tremendous strength, uniformity, versatility and economy. The producers of Malleable castings are anxious to assist you in getting maximum "usability." Why not let their modern design, testing and production facilities work for you?

Send for Special Data Unit

Your copy of Data Unit No. 101 containing additional information on the benefits you can derive from Malleable iron castings is available from any member of the Malleable Castings Council. If you wish, you may direct your request to **Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.**

A quick review of control timer types . . .

INTERVAL TIMERS — for accurate time control where frequent changes in setting are required.

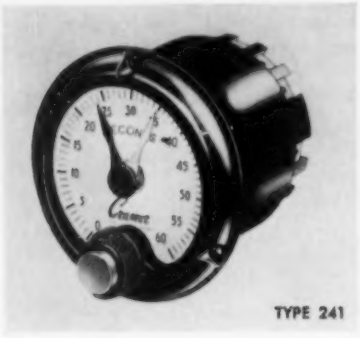
An interval timer consists basically of a constant-speed motor, an arm or cam, and a switch. The user simply sets the mechanism manually to the desired time interval. This action transfers switch contacts that start the timer motor. The motor then drives the arm or cam to the set point, where the switch is returned to its original position and the motor shuts off. A variety of dials, knobs, push-button start, automatic reset features, special housings and additional load switches may be used, but the basic operation is the same in all cases.

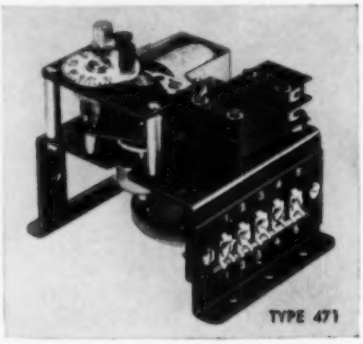
TIME DELAY RELAYS — to introduce an accurate and adjustable delay between the closing of a control circuit and the actuation of one or more independent load switches.

Again, a constant-speed motor drives a set of precision-cut cams from an adjustable starting point to a later point where one or more load switches are transferred. The unit continues to the end of its cycle, at which point the motor shuts off and the timer remains "timed out" until it is reset. Optional automatic reset, various clutching devices, and a wide selection of wiring arrangements make the time delay relay a highly versatile control with countless uses.

CYCLING TIMERS — to control a repeated sequence of operations in a definite time relationship which does not require frequent change.

The basic difference between a cycling timer and a time delay relay is that the cycling timer continues to run, cycle after cycle, until it is shut off. The single-pole double-throw load switches are transferred back and forth, at exactly determined times, by cams fixed to the motor shaft. Multiple load switches, an almost endless number of cam combinations, excellent accuracy, and a wide range of basic cycle speeds make the cycling timer an ideal program-control device in many processes.


TYPE 241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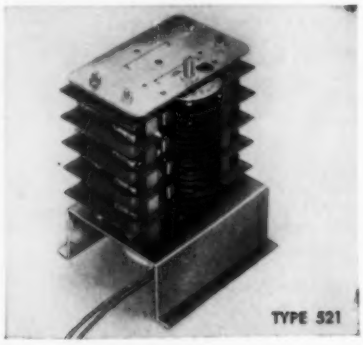
TYPE 521

. . . you can choose at a glance from this table

CLASS	INTERVAL TIMERS		TIME DELAY RELAYS					CYCLING TIMERS	
CRAMER TYPE	241	271	310	330	440A	412	471	511-21	571
Time Ranges	6 s to 24 h	45 s to 24 h	15 s to 120 s	20 s to 80 s	15 s to 3 h	6 s to 24 h	15 s to 24 h	6 s to 48 h	60 s to 3 h
Load Switches (SPDT)	1	1 or 2	1	1 or 2	1 to 5	1	1 or 2	1 to 8	1 to 4
Automatic Reset	Yes	No	Yes	Yes	Yes	Yes	Yes	—	—
Repeat Accuracy (% of total range)	¼%	½%*	½%	¾%	½%	¼%	2%	½%	1½%
Progress Indication	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No
Adjustable	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Operated by:									
Momentary contact	No	No	No	No	Yes	Yes	Yes	No	No
Sustained contact	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mounting	Panel	Back Panel	Panel	Surface	Surface	Panel	Surface	Surface	Surface
Unit List Price	$24.00	$ 8.00 or $10.00	$27.00	$18.00 or $23.00	$42.00 to $66.00	$42.00	$23.50 or $27.50	$16.00 to $44.00	$ 8.50 to $11.50
Motor & clutch rating	All standard voltages in 50, 60 and 400 cps AC, and in DC								

**Exclusive of human setting error*

LEARN MORE about these and other basic timing devices from Cramer's complete line. Write for free bulletins on the types that interest you — or describe your problem and let us help you solve it.

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FOR HIGH-VOLUME COMMERCIAL USE

Economy is usually a primary consideration in high-volume commercial sealing applications. The Gits Commercial Seal Division specializes in design and manufacture of these and other seals for just such applications — with this economy requirement in mind.

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For all types of water pumps. Useful in high-volume appliance and domestic water pump sealing applications. Rugged, durable, efficient. Specified where performance must be combined with economy.

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A factory-assembled unit-type seal for household appliance manufacturers and other small-budget users — Disposal Machines, Washing Machines, Refrigerators.

Plus

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UNIT SEAL

A complete packaged sealing unit containing both rotating and stationary seal faces enclosed in metal housing. Used on Speed Reducers, Gear Motors and many other types of Power Transmission Equipment and Machine Tools.

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An extra-rugged carbon- or bronze-faced seal, for more compact installation in heavy machine tools and other industrial machinery.

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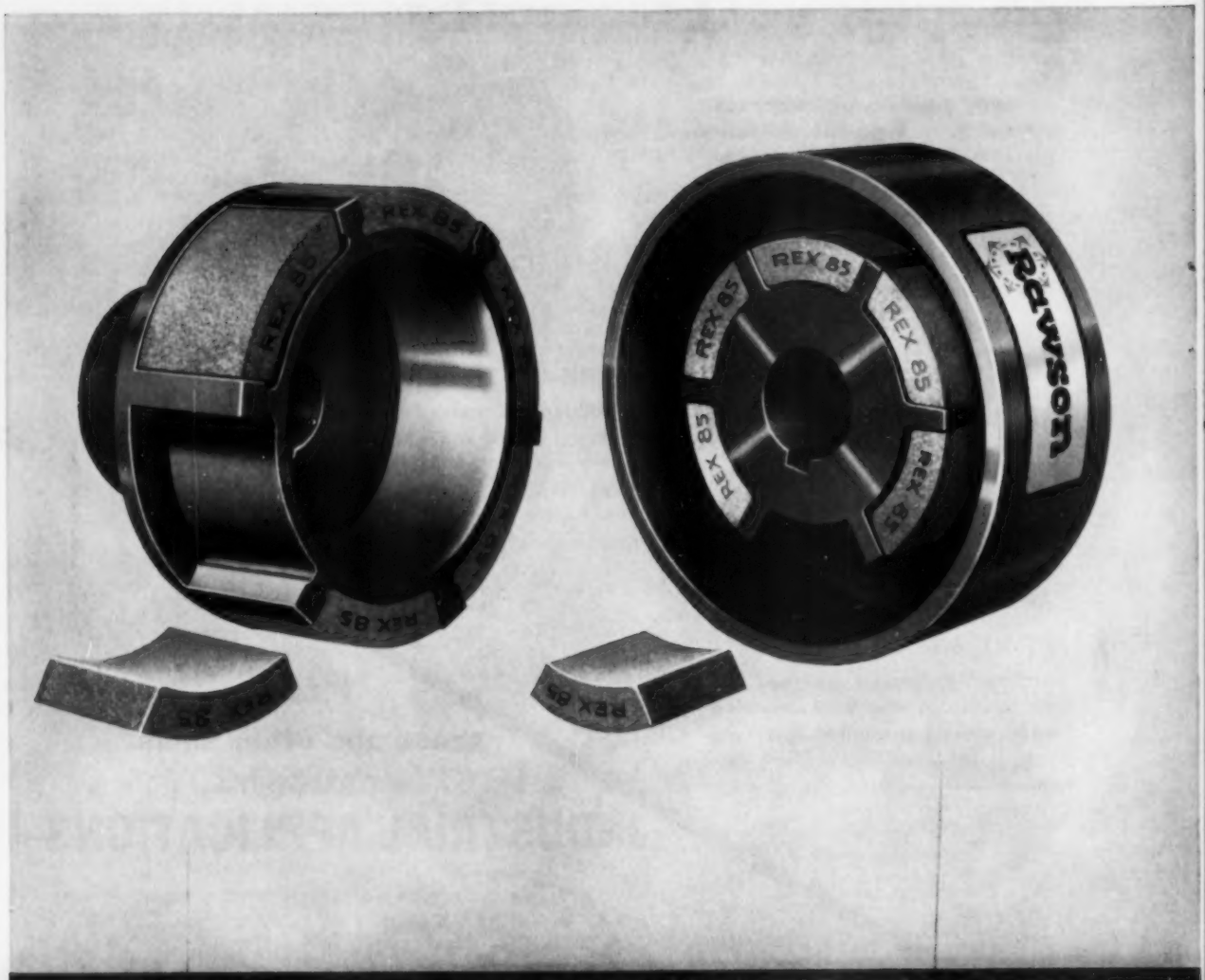
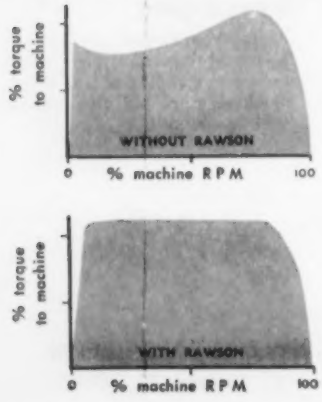
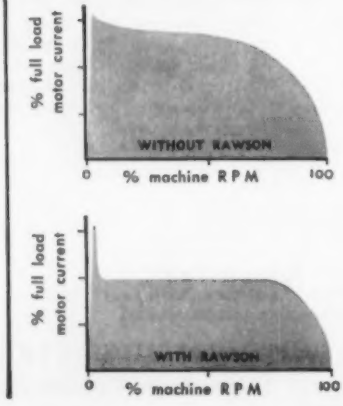


How Rawson Improves Motor Performance

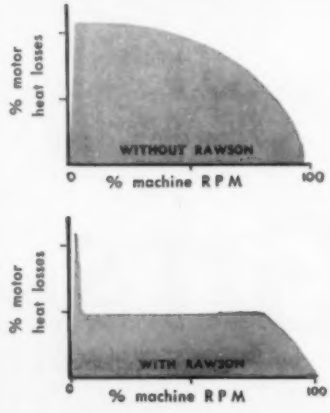
delivered starting torque



motor starting current



motor heat losses



"no load" Starts

Specify Rawson

Automatic Centrifugal Clutches and Clutch Couplings

Here is a major break-through in the development of automatic centrifugal clutches and clutch couplings! Rawson clutches and clutch couplings are designed with patented, exclusive metallic friction shoes instead of using fluid coupling devices or "brake lining" type materials. They deliver 100% slip-free power, provide full overload protection, permit smooth and gradual starting of high inertia equipment. This eliminates the need for costly special high torque starting motors and low-voltage starting equipment.

The segments, or shoes, in Rawson clutches and clutch-couplings are free-moving parts. As the driving half of clutch picks up speed, centrifugal force causes the shoes to contact the inside surface of the outer race, which is attached to the load or driven equipment. The shoes slip momentarily until friction at full speed causes the driven half to rotate in complete engagement with the driving half, both members then rotating as a unit without slippage or power loss. Jamming or overload of driven equipment causes clutch to slip — protecting motor against excessive overloading.

Rawson clutches and couplings drive in either direction and transmit up to 2,000 H.P. from nearly every motive source including A.C. and D.C. motors, diesel and gasoline engines or turbines. They function as direct couplings or as indirect drives through V-belts, chains or gearing and can be furnished with delayed shoe engagement for standby or dual drive units with load limit on starting or running. Rawson clutches and couplings are simple in design, fast and easy to install, entirely mechanical for trouble-free operation and they never require adjustment.

For increased efficiency, lower first costs, reduced maintenance and utmost protection even for the most delicate driving and driven equipment, specify Rawson clutches and clutch couplings. Ask your Rawson distributor or write us direct for your free copy of Rawson Catalog No. 141.

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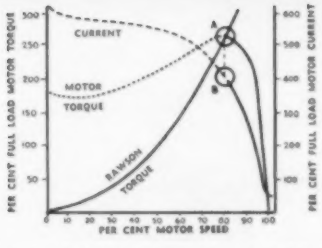
World's Largest Exclusive Manufacturer of Over-running Clutches

and Protects Motors

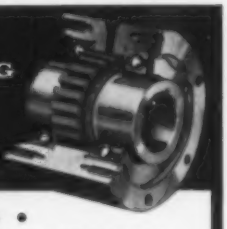


Using Rawson clutches or clutch couplings in a start-drive system lets you switch from costly high-torque motors to smaller standard, general-purpose motors for starting high-inertia loads.

Chart above shows how Rawson permits a standard NEMA "B" motor to start without load. The clutch does not fully engage until peak motor torque speed (A) is reached. Motor acceleration time is cut to a fraction of a second, decreasing the peak current period and allowing more efficient motor operation (B).

Thus, expense of reduced-voltage equipment is eliminated with the Rawson cushioned "no-load" starts, even on the heaviest machinery.

FORMSPRAG OVER-RUNNING CLUTCHES . . . UNIVERSAL APPLICATION!



OVER-RUNNING • INDEXING • BACKSTOPPING

Modern Formsprag sprag-type clutches are practically unlimited in power transmission applications. They are universally used in automotive, aircraft and general industries. Complete range of capacities from small clutches at 50 in. lbs. to large bore backstops up to 136,000 ft. lbs. Complete Formsprag standard line includes bore sizes from ⅜" to 12". Specials engineered to your requirements. Write for the new Formsprag catalog.

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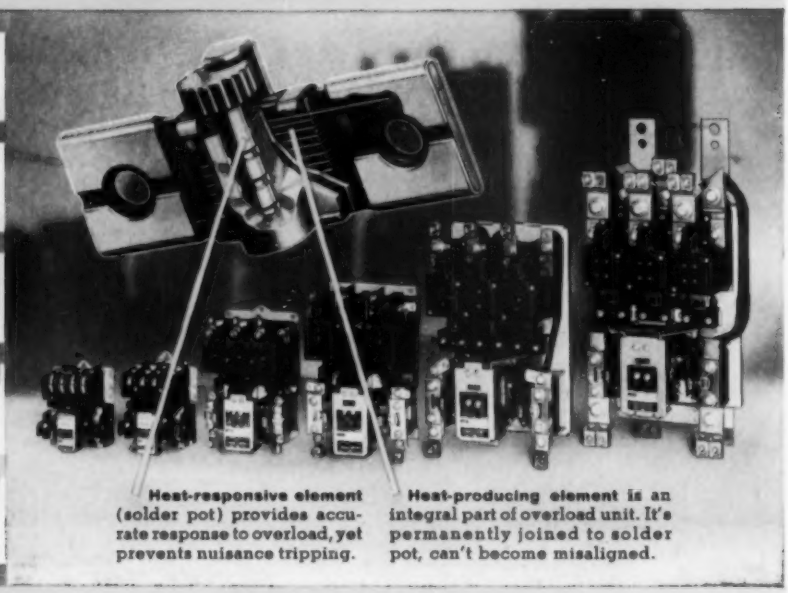
YOU PAY FOR OVERLOAD PROTECTION

...BE SURE YOU GET IT!



Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.

Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.

Only ONE-PIECE Overload Relays can give 100% Protection Only with ONE-PIECE construction can you *know* you've installed the heater correctly. Only with ONE-PIECE construction can you *know* the heater is exactly centered, or properly positioned, so that it performs according to its rating. Only with ONE-PIECE construction can you *know* your starters will not operate without the thermal units properly installed. Only with ONE-PIECE construction can you *know* your motors have full protection.

Only Square D has ONE-PIECE Construction ONE-PIECE construction *eliminates* any possibility of heater misalignment. Square D melting alloy thermal overload relays can be installed only one way. They are tamper-proof. They are factory-assembled, are *individually* calibrated and tested. Repeated tripping will not affect their accuracy.

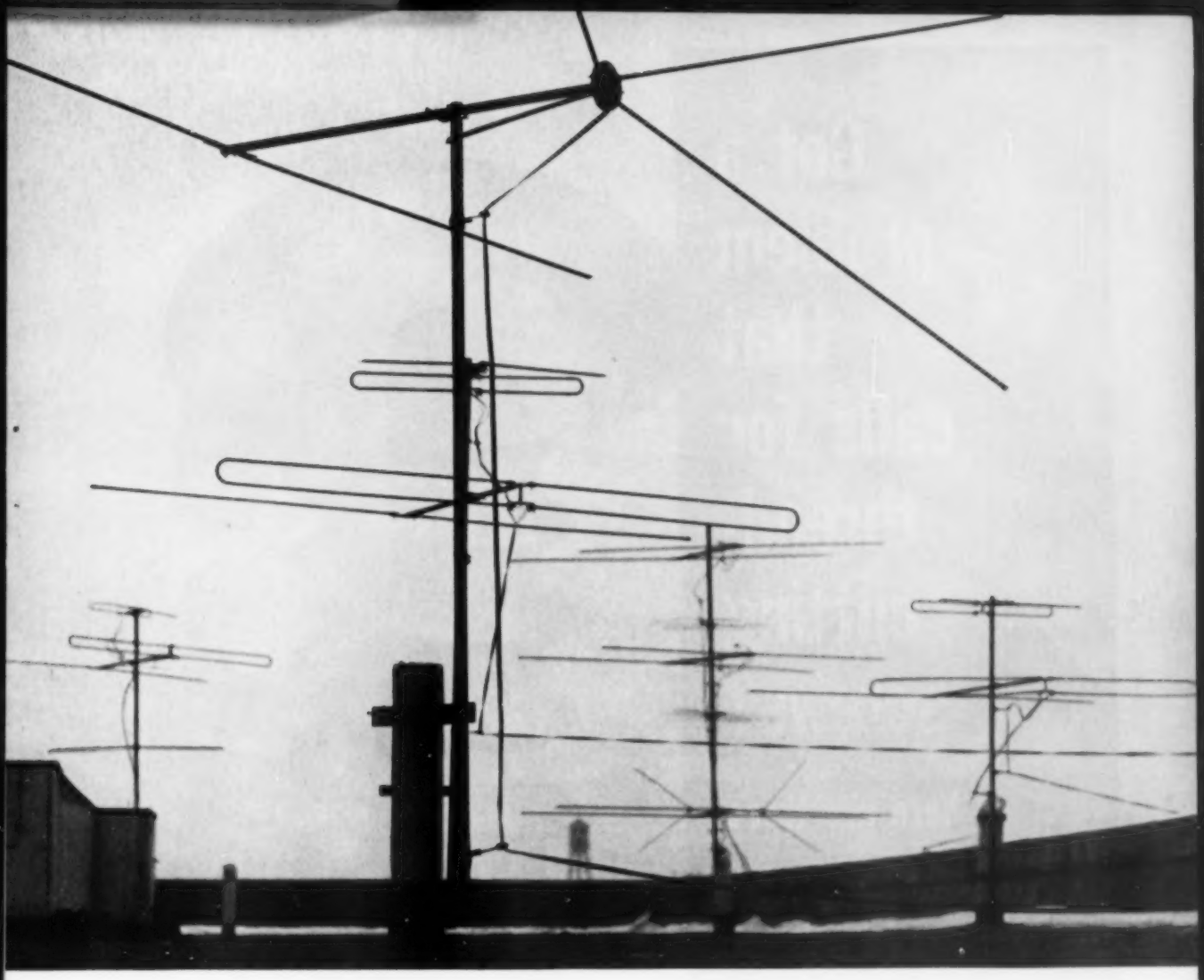
Insist on Square D starters with melting alloy thermal overload relays

LET US PROVE IT!

Let your Square D Field Engineer show you **1** how one-piece construction is accomplished and how easy it is to mismatch separate heaters and solder pots— **2** an endurance tester to prove that overload units can be reset repeatedly without damage while the solder is liquid— **3** a tripping time tester to compare various types of melting alloy units and to prove that tripping time won't change after repeated operation.

***Write** for Bulletin SM-275 for the complete story on Square D starters with ONE-PIECE thermal overload relays. Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin*

SQUARE D COMPANY



WHICH ONES WILL LAST (and last, and last!)?
THOSE MADE OF WEIRKOTE® ZINC-COATED STEEL!

Steel tubing that's protected against corrosion even under the most trying circumstances. Steel tubing that's easily fabricated to meet the most exacting specifications.

That's what you get in tubing made of Weirkote zinc-coated steel!

Weirkote's zinc coating—applied by the continuous process throughout, and so uniformly that every square inch is protected—is skin-tight. There's absolutely no flaking or peeling no matter how tortuous the crimping, twisting or other stresses of fabrication. In fact, Weirkote can be worked to the very limits of the steel itself.

The use of Weirkote can eliminate the need for any further coating process after fabrication. Its tight zinc coating is completely intact and remains so during fabrication and on the job. Weirkote zinc-coated steel tubing is particularly suited for jobs where weather is a factor to be taken into consideration.

Take a good long look at the possibilities and advantages of using Weirkote zinc-coated steel to meet your tubing requirements. For the complete story on Weirkote and how it can help you, write Weirton Steel Company, Weirton, West Virginia.

CIRCLE 125 READER SERVICE CARD

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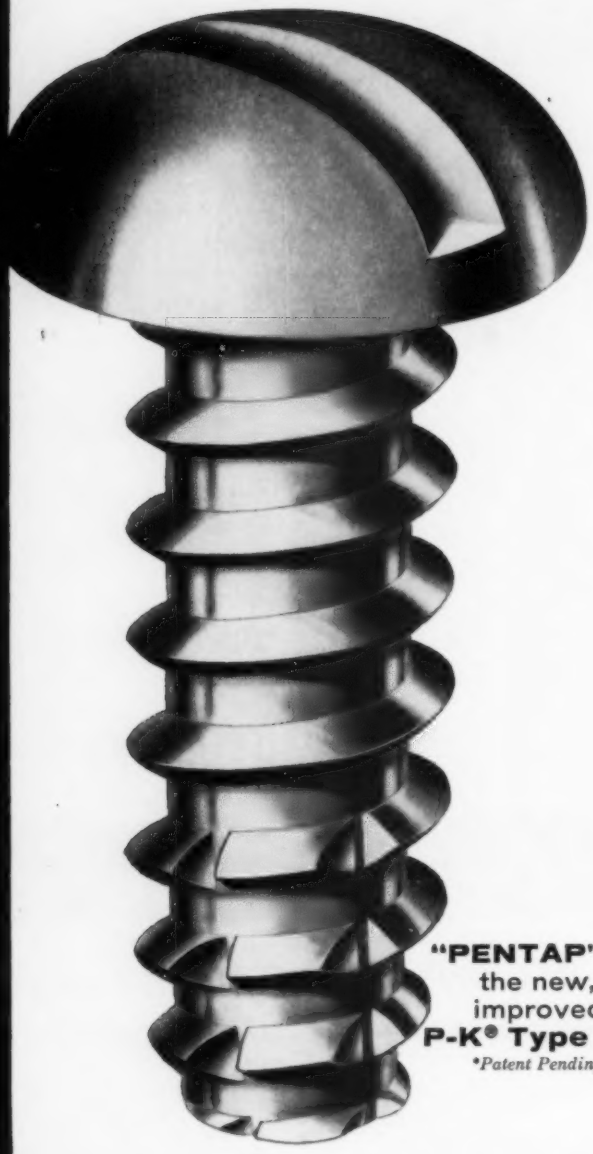
Got a problem that calls for thread-cutting screws?

here are three new, improved thread-cutting screws from PARKER-KALON!



"PENTAP"... the new, improved P-K® Type B-F
**Patent Pending*

The five cutting flutes on the new, improved P-K Type "F" and "BF" reduce pressure development by 80%! The completely formed threads on these screws have sharper cutting edges, and 5 deep flutes that are of continuous depth. These features make for better clearance of the accumulated material and assure minimum stresses in driving and avoid the possibility of stripping or galling.

For Plastics

... P-K has the new improved "Pentap", Type B-F* (formerly F-Z). It combines the five thread-cutting flutes of the Type F screw with the coarse-pitch, widely-spaced threads of the P-K Type B. The new thread-cutting "Pentap" Type B-F distributes cutting pressure evenly, lets chips drop to the bottom of the hole, and prevents cracking of material. It is designed for making fastenings to comparatively thin sections and bosses in friable and brittle plastics.

The New
P-K Type L
†U.S. Patent 2,350,346

The New,
Improved
P-K Type F
***Patent Pending*

For Nylon

. . . Only Parker-Kalon has a completely new tapping screw, especially developed for use in this material. It's called, the P-K TYPE L†. It functions as a combination thread-cutting and thread-forming screw in that it cuts a small amount of the Nylon while allowing the full diameter threads to form. The new Type L offers a particular advantage in Nylon assemblies which must be disassembled for service because *the P-K Type L can be readily removed and replaced without stripping or galling.*

For Castings or Forgings

. . . P-K's hardened Type F** tapping screw has been developed for use in friable, granular or brittle materials such as ferrous or non-ferrous castings and bronze or brass forgings. The pilot of the P-K Type F, with its five tapping flutes, cuts a machine thread as the screw is turned in and makes a speedy, thoroughly reliable fastening.

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. . . The new, improved P-K Type F** reduces driving torque in structural steels and sheet metals. By *cutting* its mating thread, the P-K Type F obtains a close fit which assures a fastening secure against loosening under vibration. The new P-K Type F has greater resistance to torque, sheer and tension loads than a machine screw in a tapped hole.

For Resin Impregnated Plywood

. . . For fastenings in these materials, the versatile P-K Type F** does the job with complete dependability. The tough, specially heat-treated Type F swiftly cuts its way into the material, grips with rugged strength, and stays tight and secure.

FOR SAMPLES OF THESE NEW IMPROVED P-K THREAD-CUTTING SCREWS contact your local *P-K "Bulk-Stocking" Distributor.* Not only is he prepared to furnish samples and full technical data, but he can supply your plant with all of its fastener requirements in production quantities, because he warehouses P-K fasteners in bulk. *Phone him for data and samples, today.*

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fasteners

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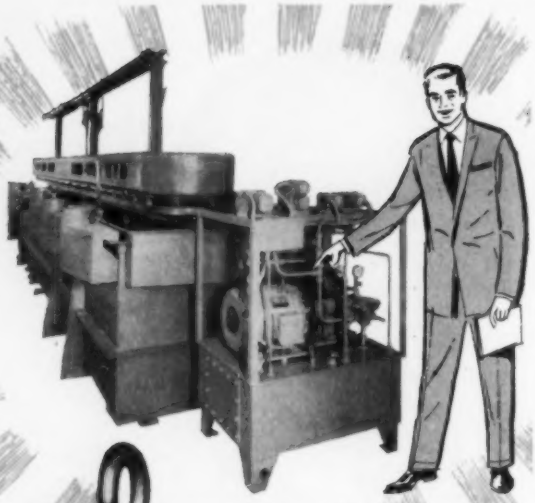

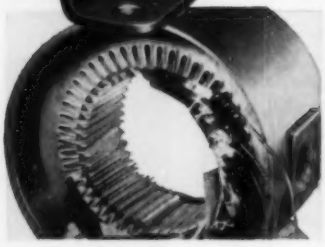

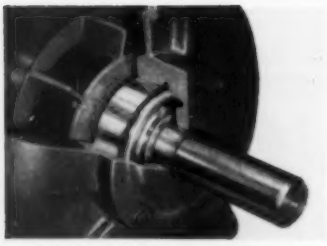

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build motors from
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BEARINGS POSITIVELY SEALED . . . Double row width ball bearings, sealed on both sides, eliminate frequent re-lubrication. Grease sealed in extra-large reservoirs, resists dust, temperature, humidity and high operating speeds.

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Udylite Corporation's famed Automatic Plating Machines put a shine on everything from sewing machine parts to automobile bumpers. R&M Totally Enclosed Fan Cooled Motors power the hydraulic system of these precision machines quietly, smoothly and without vibration. But most important they successfully combat the severe corrosive atmosphere common to all plating operations. R&M Motors are completely protected against this serious motor menace.

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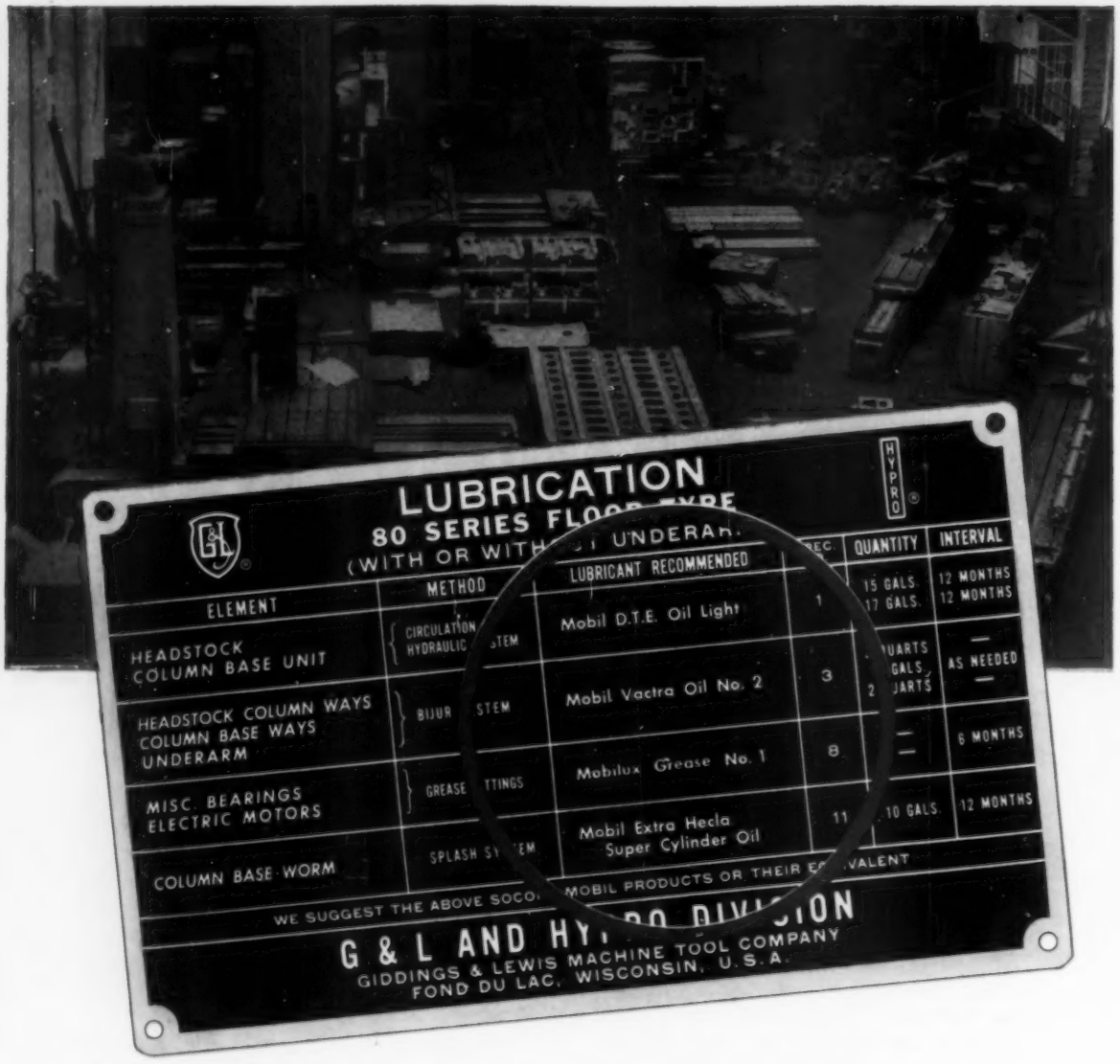

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Correct Lubrication

The majority of the world's machine builders specify *Mobil* on the lubrication plate attached to each of their machines. And for good reason! Engineers from Mobil's Engine Builder's department work closely with machine designers. They make available their deep knowledge of lubricant characteristics and machine requirements . . . help assure that each lubrication system is designed to perform with top efficiency. Mobil's lubrication specialists even check machines after installation and advise the builder of how the machine lubrication system performs in actual operation.

No wonder more machine manufacturers recommend *Mobil* be used in their machines than any other brand! The lubrication plate is the proof—look for it!

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PERSPECTIVES

in design and development . . .

Where Did You Go? Out. What Did You Find? Nothing

This title is a play on the words of Robert Paul Smith's popular book, "Where did you go? Out. What did you do? Nothing." And it sums up Dr. Heinz Haber's feeling on the net gain to science from some of the outer-space exploration projects now planned. "Everyone can enumerate thousands of other scientific experiments that are infinitely more promising and profitable," says Haber, who is scientific consultant to the Columbia Broadcasting System. He is deeply worried about the public's attitude toward science and scientists in the world today, and the way that the progress of science seems to be boxed in by military ramifications.

Take atomic energy, for example. The potential military applications of atomic energy dominate the political situation in the world today, says Haber; the nonmilitary applications have been relegated to a back seat.

And space exploration? It started out well enough in July 1955, when the Vanguard project was announced by the US to advance the cause of science as an integral part of the International Geophysical Year. Then came the first Sputnik, says Haber, "and the satellites were no longer tools of earth research. They become symbols of a nation's capabilities to wage war and to impress the world with one's technical superiority."

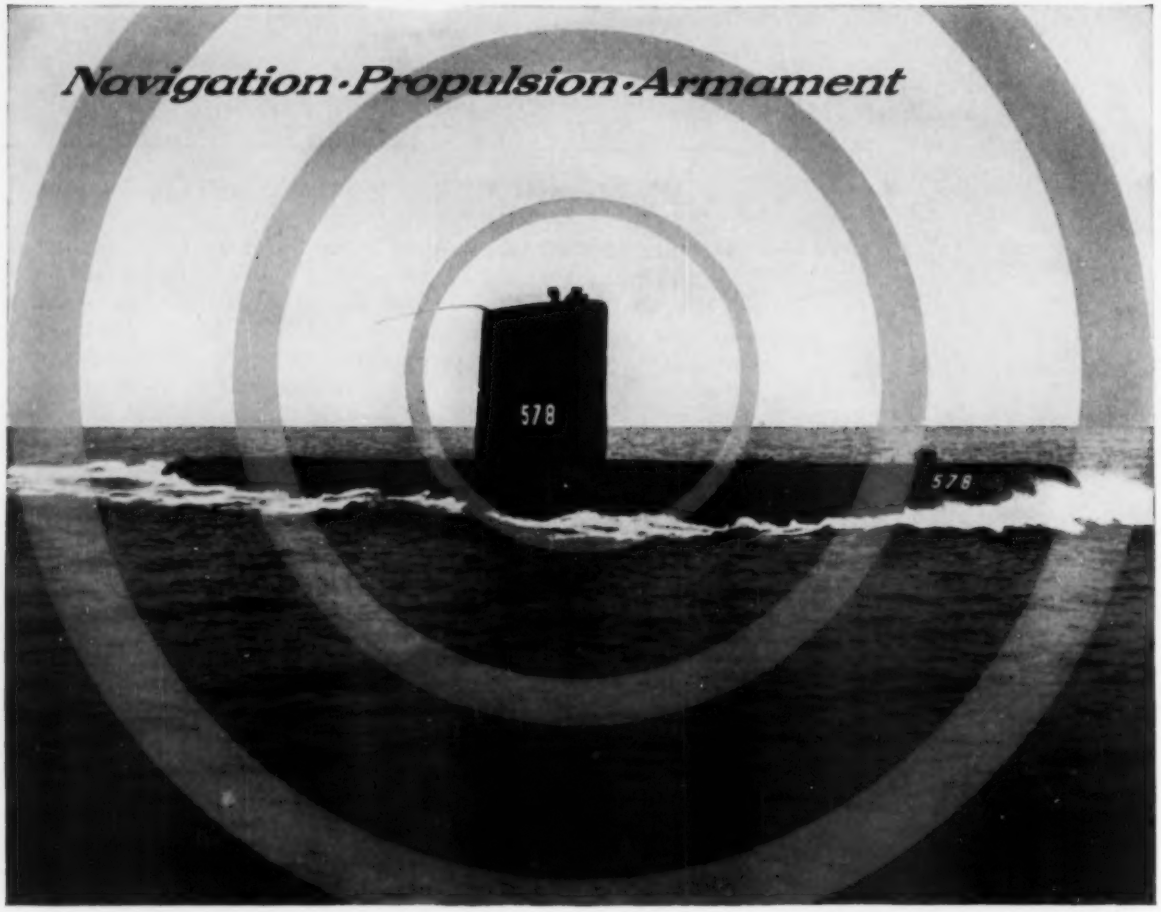
Haber is not a space isolationist. He realizes the US has no choice but to make tremendous space efforts—in the interests of national defense and worldwide reputation. But he feels the present situation of space science has our public in an utter state of confusion about the role of science in civilization. If the public does not fully understand the motivations of scientists, Haber feels, we will be able to get public support for future space projects only if they can be justified by military necessity. But science here is more than the design of military hardware. Haber points out it also can mean communications-relay satellites, world-wide television networks, and the eventual control of weather.

What's in It for Me?

A current space project is the lunar probe that will circle the moon and bring back pictures of the side of the moon that we have never seen. "So what?" is Haber's reaction. Those pictures will have little value as building blocks for further scientific progress. There is an overwhelming probability —almost a certainty—that the other side will look just like the side of the moon we have always likened to cheese. "No scientist in his right mind would spend a lot of money and effort to ascertain a certainty," Haber says. "And the same arguments hold for the exploration of planets."

"In terms of human affairs, we can say that there are only two important bodies in the solar system: the sun and the earth. The other planets are the chemical dungheap of the solar system, and it is not likely that we shall find truly earth-shaking scientific novelties in the masses of noxious chemicals that constitute the outer shells of the planets."

What about the argument that space exploration is in the interest of public science, because it will appeal to the young mind of today and cause him to pursue a scientific career? This brings up a question of scientific integrity, Haber feels. Is it proper to fire the scientific imagination of young people by misrepresenting the true goals and ideals of science? "If we want to raise a generation of true scientists, we must give them a true picture of scientific ideals and of the seriousness of the scientific age, so that they can look upon us as mature and responsible people, and not as interplanetary Boy Scouts who somehow failed to grow up." —Paul Anderson



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U.S. Atomic Subs Depend On N/D Ball Bearings In Over 100 Vital Positions!

Some of the most unique and precise equipment ever engineered is in United States atomic subs . . . with New Departure bearings in many vital positions!

In the submarines' guidance system, New Departure gyro ball bearings help contribute to unerring undersea navigational accuracy. These bearings have been credited with reducing random drift rate to 0.25 degrees per hour.

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NOTHING ROLLS LIKE A BALL

Product Engineering

HORIZONS

March 16, 1959

does QUALITY really pay?

A Steuben or a dime-store cocktail glass will hold the same amount. They may weigh the same, wash with equal facility, look very much alike—both are glass and the shape is traditional. One costs $10, the other 10 cents. Yet both sell. Why?

The Steuben glass is hand-crafted of colorless glass. It represents care and attention to detail, faultless design and manufacture, no distortion in shape or to the color of the drink. To the user it spells quality, distinction, exclusiveness.

In our mass-production society, this represents a paradox, an archaic survival. It also proves that in the area of aesthetics and good taste, some buyers will pay a premium that is ridiculous from any practical point of view, providing the aesthetic object is not produced in quantity.

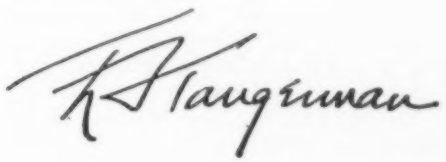
There is a lesson here for the engineer—that price is not necessarily the only criterion. There is still a place for intrinsic quality, for design and manufacture done to the top standard. And some designers and makers have recognized it.

One case in the area is of course the ICBM. But a commercial one is exemplified by the new IBM high-speed printer. This is an ultra-expensive machine that can print 120,000 characters a minute. It is so expensive that most users will lease rather than buy it. The cost for downtime for any reason soon mounts into 4-figure numbers —so great that the machine must be designed both for maximum rapidity of interchange of faulty units—which is familiar—and for maximum service life between such interchanges—which is not. So stainless, nylon, platinum wire and similar costly materials are used. The printer is designed for maximum wearability, manufactured to extremely close tolerances, inspected and assembled with the utmost care.

For more everyday examples, consider the costly watch, a fine camera, or precision measuring instruments. None is at the mercy of the stylist; some are almost dowdy. But the engineering is built into them, guarding a reputation for accuracy, reliability, dependability—quality.

In our economy, it is easy to "make a buck"—for a time. But the maker who assumes that only quantity and price are ultimately important is the maker who loses his shirt. One of the virtues of a high standard of living is that it eventually develops a high standard of selection, where the shoddy product is so tagged.

There is a growing future for the man who will not compromise with inferiority, who makes only a Steuben glass.



NUMERICAL INTEGRATION

simplifies complex design

It's a tabular method for evaluating integrals, but surprisingly accurate. Here are the basic concepts applied in detail to six examples of beams and shafts with complex loading.

ERIC E UNGAR
Senior Engineering Scientist
Bolt Beranek and Newman, Inc, Cambridge, Mass.

There are good reasons for calling on numerical integration to handle the analysis of machine parts or structures with complex shapes and loading. This tabular method is based on simple concepts, so doesn't require a knowledge of higher mathematics; it will even produce results where analytical methods fail. It can be applied to determine the value of any integral, no matter how complicated, and to any degree of accuracy required. Yet confusion often arises when it is applied to more complicated design problems. Possibly this is why the method is not employed as frequently as it should be.

In this article, the basic concepts are explained first, then the versatility of the method is demonstrated by applying it to these six problems carefully selected to cover all aspects of the approach: (1) evaluation of a simple integral, (2) analysis of a tapered cantilever with varying loads, (3) deflections in statically indeterminate beams, (4) buckling of a stepped column, (5) buckling of a pin-headed column, (6) torsion of a tapered shaft.

A second article will show the method can also be applied, with slight variation, to numerical solution of differential equations that arise in dynamic systems.

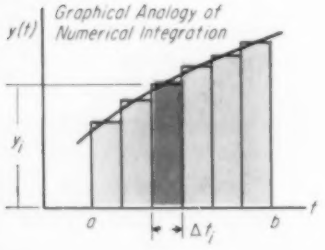
BASIS FOR NUMERICAL INTEGRATION

Numerical integration makes use of the fact that the area beneath a plotted function is proportional to the integral of that function. Therefore, to integrate a function y (t) in the interval from $t = a$ to $t = b$, the interval is divided into a number of equal increments, the function is evaluated at some value of t within each interval, each function value is multiplied by its corresponding interval, and the resulting products are summed up. The limit of this sum as the intervals become infinitely small and as their number becomes infinitely large is defined as the integral

$$\int_a^b y(t)\,dt = \lim_{\substack{n\to\infty \\ \Delta t\to 0}} \sum_1^n y_i\,\Delta t_i \qquad (1)$$

where Δt_i denotes the i^{th} increment and y_i the corresponding value of the function.

The product $y_i\,\Delta t_i$ corresponds to the area shown in color, in the diagram at right. The value of the integral corresponds to the entire area between the curve and t-axis, from $t = a$ to $t = b$.



The value of the finite sum will be exactly equal to that of the integral only if each y_i is taken as the mean value of y occurring in the interval Δt_i. But the mean value is not easily found in practical cases, and one has to settle for some value close to it. In general, if the value of y at the midpoint of Δt_i is taken as y_i, a good approximation will result. There are more elaborate methods for obtaining a better approximation to the mean value but at the expense of simplicity.

Example—Evaluating a Simple Integral

Using intervals of $t = 2$, evaluate the integral:

$$\int_2^{10} t^2\,dt$$

Stations	t	2	4	6	8	10
Obtain mean	t_m		3	5	7	9
Perform operation	$y_i = t_m^2$		9	25	49	81
Sum up	Σy_i	0	9	34	83	164

In the table, t_m = value of t at interval midpoints, y_i = value of $y(t)$ evaluated at t_m (where $y(t) = t^2$), and Σy_i denotes the cumulative summation of y_i, starting with zero at the beginning of the interval of integration. Thus from Eq. (1):

$$\int_2^{10} t^2\,dt \approx \Delta t\,\Sigma\,t_m^2 = 2(164) = 328$$

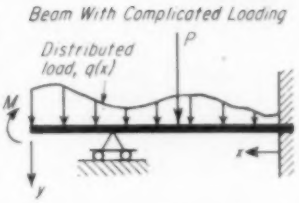
As a check, the exact value of the integral is

$$\int_2^{10} t^2\,dt = \frac{t^3}{3}\Big]_2^{10} = \frac{1}{3}(1000-8) = 330.6$$

which shows that error in the approximation amounted to only 0.5%. Smaller intervals will reduce this error; for example, with $\Delta t = 1$ (and twice the work), a value of 330.0 is obtained, for which the error is only 0.2%.

BEAM ANALYSIS

Beam analysis can be considered a series of integrations leading successively from the load characteristics of the beam to its shear, moment, slope and deflection characteristics. Of the four, it is usually the moment and deflection data that interest a designer. Incorporating the value for maximum moment in equation $S = Mc/I$ gives max induced stress, which indicates if the beam can take the loads; and the max deflection indicates rigidity.



Thus, for a beam subject to a distributed load $q(x)$, as illustrated, the shear V_q caused by this load is

$$V_q = \int q(x)\,dx + V_o \qquad (2)$$

where x is measured along the beam length and V_o is a constant of integration. Total shear at each point is obtained by adding the shear from concentrated loads.

Then, the bending moment M at each point is

$$M = \int V\,dx + M_o \qquad (3)$$

where M_o is a constant of integration.

Curvature $K = M/EI$ can be evaluated at each point by using the modulus of elasticity E of the material and the moment of inertia I of the cross-section at each point. Integrating the curvature gives slope θ at any point:

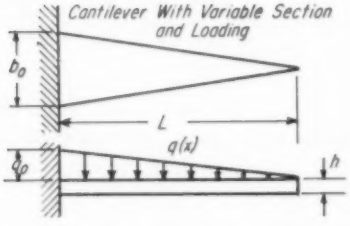
$$\theta = \int K\,dx + \theta_o = \int \frac{M}{EI}\,dx + \theta_o \qquad (4)$$

Integrating again gives the deflection equation:

$$y = \int \theta\,dx + y_o \qquad (5)$$

Each integration introduces a constant which must be evaluated from known boundary conditions.

Example—Tapered Cantilever



When using numerical integration it does not matter how the beam varies in loading or cross-section. It is simply divided into a number of stations—six, in this case—and the load and cross-sectional data for each station are included into that station's computations.

Let us apply the method to a tapered cantilever with varying loads, as illustrated, and compare the results with answers from analytical methods.

Conventional methods of integration for this problem yield

$$y_{max} = \frac{L^4 q_o}{2b_o h^3 E}$$

	Stations	0	1	2	3	4	5	6	Factor	Units
Loading	q(x)	6	5	4	3	2	1	0	$q_o/6$	lb/in.
Mean	q_m		5.5	4.5	3.5	2.5	1.5	0.5	$q_o/6$	lb/in.
Sum up	$V = V_q^{(2)}$	−18.0	−12.5	−8.0	−4.5	−2.0	−.5	$0^{(1)}$	$\frac{q_o(\Delta x)}{6}$	lb
Mean	V_m		−15.25	−10.25	−6.25	−3.25	−1.25	−.25	$\frac{q_o(\Delta x)}{6}$	lb
Sum up	$M^{(2)}$	36.50	21.25	11.00	4.75	1.50	.25		$\frac{q_o(\Delta x)^2}{6}$	in.-lb
Width	b	6	5	4	3	2	1	0	$b_o/6$	in.
Inertia	I	6	5	4	3	2	1	0	$b_o h^3/72$	$in.^4$
Constant	K = M/EI	6.08	4.25	2.75	1.58	.75	.12		$\frac{12q_o(\Delta x)^2}{b_o h^3 E}$	$in.^{-1}$
Mean	K_m		5.16	3.50	2.16	1.16	.44	.6		
Sum up	θ	0^1	5.16	8.66	10.82	11.98	12.42	12.48	$\frac{12q_o(\Delta x)^3}{b_o h^3 E}$	$in.^{-1}$ radians
Mean	θ_m		2.18	6.91	9.74	11.40	12.20	12.45		radians
Sum up	y	$0^{(1)}$	2.18	9.09	18.83	30.23	42.43	54.88	$\frac{12q_o(\Delta x)^4}{b_o h^3 E}$	in.

Notes: (1) Known boundary conditions: zero shear V at beam end, and zero slope θ and deflection Y of beam base. (2) to save work, integrate from right to left.

whereas the numerical integration procedure led to

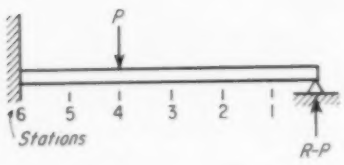
$$y_{max} = \frac{(54.88)\,(12)\,q_o\,(\Delta x)^4}{b_o h^3 E} = \frac{(54.88)(12) q_o\,(L/6)^4}{b_o h^3 E} = .508\,\frac{L^4 q_o}{b_o h^3 E}$$

This is an error of only 1.6%.

NUMERICAL INTEGRATION (Cont.)

Example—Statically Indeterminate Beam

Numerical integration will easily work with statically indeterminate problems. One merely carries the unknown reactions through the calculations in algebraic form and then makes the proper substitution for them at the end. The problem in the diagram is also solved analytically to check the accuracy of the method.



	Stations	0	1	2	3	4	5	6	Factor	Units
Loading	Concentrated	$-R$	0	0	0	1	0	$1-R$[1]	P	lb
Sum up	V	$0/-R$[2]	$-R$	$-R$	$-R$	$-R/1-R$	$1-R$	$1-R/0$[2]	P	lb
Mean	V_m		$-R$	$-R$	$-R$	$-R$	$1-R$	$1-R$	P	lb
Constant	$K=M/EI$	0[3]	$-R$	$-2R$	$-3R$	$-4R$	$-5R+1$	$-6R+2$	$\frac{P(\Delta x)}{EI}$	$in.^{-1}$
Mean	K_m		$-.5R$	$-1.5R$	$-2.5R$	$-3.5R$	$\binom{-4.5R}{+0.5}$	$\binom{-5.5R}{+1.5}$	$\frac{P(\Delta x)}{EI}$	$in.^{-1}$
Sum up	θ[4]	$\binom{18.0R}{-2.0}$	$\binom{17.5R}{-2.0}$	$\binom{16.0R}{-2.0}$	$\binom{13.5R}{-2.0}$	$\binom{10.0R}{-2.0}$	$\binom{5.5R}{-1.5}$	0[3]	$\frac{P(\Delta x)^2}{EI}$	radians
Mean	θ_m	$\binom{17.75R}{-2.0}$	$\binom{16.75R}{-2.0}$	$\binom{14.75R}{-2.0}$	$\binom{11.75R}{-2.0}$	$\binom{7.75R}{-1.75}$	$\binom{2.75R}{-.75}$		$\frac{P(\Delta x)^2}{EI}$	radians
Sum up	y	0[3]	$\binom{17.75R}{-2.0}$	$\binom{34.50R}{-4.0}$	$\binom{49.25R}{-6.0}$	$\binom{61.00R}{-8.0}$	$\binom{68.75R}{-9.75}$	$\binom{71.50R}{-10.5}$[5]	$\frac{P(\Delta x)^3}{EI}$	in.
Substitute for R	y[6]	0	.609	1.071	1.240	.967	.356	0	$\frac{P(\Delta x)^3}{EI}$	in.

Notes: (1) From statics, RP = reaction at left support, therefore $(1-R)P$ = reaction, right support; numerical values for P will reduce the complexity. (2) x/y indicates values changes from x to y at station. (3) Known from boundary condition. (4) Integration from right to left. (5) $y = 0$ at station 5, so that $71.50R-10.50 = 0$, and $R = 0.147$.

The exact solution gives:

$$R = \frac{4}{27} = 0.148, \quad y \text{ at } P = \frac{11}{2187}\frac{PL^3}{EI} = 0.005{,}02\frac{PL^3}{EI}$$

whereas, by numerical integration:

$$R = 0.147, \quad y \text{ at } P = 0.967\frac{P(\Delta x)^3}{EI} = \frac{.967}{(6)^3}\frac{PL^3}{EI} = 0.004.47\frac{PL^3}{EI}$$

Although R is approximated quite quite closely, the error in deflection under load (about 9%) is fairly large because there are only a small number of intervals between the point considered and the boundary points. Error is reduced to 3% with 12 intervals instead of six.

CRITICAL LOADS OF COLUMNS

When a long slender column buckles, it is deflected so that its centerline conforms to some deflection curve $y = y(x)$, with respect to any convenient set of axes, Fig. 5. If the axis system is chosen so that the bending moment at any position along the column is $M = -Py$, then the differential equation for beam deflection can be used to give the differential equation for column deflection

$$\frac{d^2y}{dx^2} = -P\frac{y}{EI} \tag{6}$$

The smallest value of P which satisfied this equation in conjunction with a non-zero deflection $y(x)$, which also satisfied the boundary conditions, is defined as the critical load P_c of the column.

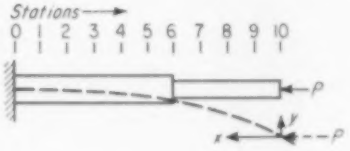
The relation between columns and beams indicates how beam-analysis methods may be extended to columns. The difficulty of not knowing the deflection curve and the load corresponding to it can be overcome by a process of successive approximations, as is done in some of the "relaxation" procedures.

The method discussed here has the advantage that it does not require a well-trained knowledge in difference calculations. It assumes a set of deflections which satisfy the boundary conditions, then performs the integrations indicated to obtain a new set of deflections. The new deflections involve the unknown load P as a factor, and in general will differ in shape from those originally assumed.

The process is then repeated, starting with the newly calculated deflections, until the shape of the deflection

curve obtained from the calculations approximates the assumed shape as closely as desired. (It can be proved that this process always converges.) When the calculated deflections are proportional to those assumed, the factor of proportionality involving P may be used to calculate the critical load. This procedure gives the deflection curve only within a multiplicative constant, as do exact solution methods.

Example—Buckling of a Stepped Column



The stepped column shown at right will buckle under a certain load. The change in diameter makes it difficult or impossible to handle by usual strength-of-material methods. (Solution is possible, however, using concepts of elastic stability theory.) Nevertheless, this problem poses no difficulty if numerical methods are used, as follows.

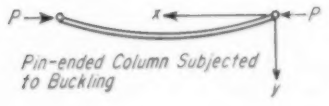
Station	0	1	2	3	4	5	6	7	8	9	10	Factor
I	←			1.000	→				.400		→	$\pi/64$
y_1	1.000	.950	.900	.850	.750	.650	.600	.400	.250	.100	0	1.0
$y'' = -\frac{P}{EI} y_1$	1.000	.950	.900	.850	.750	.650	$\frac{.600}{1.50}$	1.00	.625	.250	0	$\frac{-64P}{\pi E}$
y''_m		.975	.925	.875	.800	.700	.625	1.25	.812	.437	.125	$\frac{-64P}{\pi E}$
$\theta = y'$	0	.975	1.900	2.775	3.575	4.275	4.900	6.150	6.962	7.399	7.524	$\frac{-64P}{\pi E}(\Delta x)$
y'_m		.488	1.437	2.338	3.175	3.925	4.588	5.525	6.556	7.180	7.461	$\frac{-64P}{\pi E}(\Delta x$
y	42.67	42.18	40.75	38.41	35.235	31.310	26.722	21.97	14.641	7.461	0	$\frac{64P(\Delta x)^2}{\pi E}$
$y_2 = \frac{y}{42.67}$	1.000	.986	.955	.900	.825	.733	.625	.496	.343	.175	0	$\frac{(42.7)(64P)(\Delta x)^2}{\pi E}$
Similarly												
y_3	1.000	.990	.957	.905	.832	.744	.640	.512	.354	.182	0	$\frac{(46.4)(64P)(\Delta x)^2}{\pi E}$
y_4	1.000	.990	.957	.905	.832	.744	.640	.512	.356	.183	0	$\frac{(46.7)(64P)(\Delta x)^2}{\pi E}$

Thus, one finds here that

$$P = \frac{\pi E}{(64)(46.7)(\Delta x)^2} = \frac{100\pi}{(64)(46.7)} \frac{E}{L^2} = 0.105 \frac{E}{L^2}$$

This solution may be compared with the one obtained from elastic stability theory which is: $P = 0.104\ E/L^2$, indicating an error of less than 1%.

Example—Buckling of a Pin-ended Column



Pin-ended Column Subjected to Buckling

Consider the column diagrammed above. The deflection curve clearly must be symmetric and pass through zero at the two ends. Proceed in tabular form, as for beams, but employ eight stations ($\Delta x = L/8$), and the numerical subscripts to the deflections to indicate the order of the approximation.

Station	0	1	2	3	4	5	6	7	8	Factor
y_1 (1)	0	.1	.5	.9	1.0	.8	.5	.1	0	1.0
$y'' = \frac{d^2y}{dx^2} = -\frac{P}{EI} y_1$	0	−.1	−.5	−.8	−1.0	−.9	−.5	−.1	0	P/EI
y_m'' (mean values)		−.05	−.3	−.65	−.9	−.9	−.65	−.3	−.05	P/EI
$\theta = y' = \frac{dy}{dx}$	1.90	1.85	1.55	.9	0 (2)	−.9	−1.55	−1.85	−1.90	$\frac{P}{EI}(\Delta x)$
θ_m (mean values)		1.88	1.70	1.22	.45	−.45	−1.22	−1.70	−1.88	$\frac{P}{EI}(\Delta x)$
y	0 (3)	1.88	3.58	4.80	5.25	4.80	3.58	1.88	0	$\frac{P}{EI}(\Delta x)^2$
$y_2 = \frac{y}{5.25}$ (4)	0	.36	.68	.91	1.00	.91	.68	.36	0	$\frac{5.25\ P(\Delta x)^2}{EI}$

Notes: (1) Assumed values, deflection symmetric and zero at ends. (2) Known from symmetry; integration to left and right of station 4. (3) Known boundary condition. (4) y's are divided by 5.25 so the new deflection shape may be compared to y_1.

NUMERICAL INTEGRATION (cont.)

This process may now be repeated, but starting with:

Station	0	1	2	3	4	5	6	7	8	Factor
$y'' = -y_2 \frac{P}{EI}$	0	.36	.68	.91	1.00	.91	.68	.36	0	$-\frac{P}{EI}$
y_m''		.18	.52	.80	.96	.96	.80	.52	.18	"
y'	−2.46	−2.28	−1.76	−.96	−0	.96	1.76	2.28	2.46	$-\frac{P}{EI}(\Delta x)$
y_m'		−2.37	−2.02	−1.36	−.48	.48	1.36	2.02	2.37	"
y	0	2.37	4.39	5.75	6.23	5.75	4.39	2.37	0	$\frac{P}{EI}(\Delta x)^2$
y_2	0	.380	.704	.923	1.000	.923	.704	.380	0	$\frac{6.23\,P(\Delta x)^2}{EI}$

Continuing in this manner, one finds

y_4	0	.382	.707	.924	1.000	.924	.707	.382	0	$6.310\frac{P(\Delta x)^2}{EI}$
y_8	0	.383	.707	.924	1.000	.924	.707	.383	0	$6.319\frac{P(\Delta x)^2}{EI}$

Repeating the process leads to no changes in the resulting values. From the last approximation, the value for P (equating the 4th and 5th values of y at station 4) is

$$P = \frac{EI}{6.319\,(\Delta x)^2} = 10.1\,EI/L^2$$

The exact solution for this problem is

$$P = \pi^2 \frac{EI}{L^2} = 9.87\,\frac{EI}{L^2}$$

This is an error of about 2%.

TORSION OF BARS

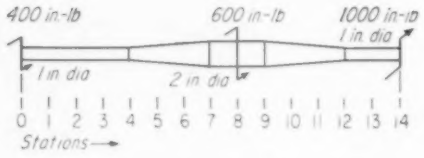
Basic relation between torque and the angle of twist ϕ is given by

$$d\phi = \frac{T}{GK}\,dx \qquad (7)$$

where T is torque or twisting moment applied to a bar of length dx, G is modulus of shear and K denotes the torsional constant of cross-section. (For circular cross-sections, K = polar moment of inertia; for square cross-sections, $K = 0.1406s^4$). A simple integration of Eq (7) thus suffices to determine the torsional deformation.

Example—Torsion of a Tapered Shaft

With the tapered shaft at right, assume a clockwise torque of 1000 in.-lb applied at the right end, and counterclockwise torques of 400 and 600 in.-lb respectively acting at station 0 and 8. The problem: determine the angle through which the sections at station 8 and 14 twist with respect to station 0.



Station T	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Factor 100 in.-lb
	←				4				→ ←			10			→	
$K_m = \frac{\pi d^4}{64}$	1.0	1.0	1.0	1.0	2.44	5.06	9.38	16.00	16.00	9.38	5.06	2.44	1.00	1.00		$\pi/64$
$\frac{d\phi}{dx} = \frac{T}{GK}$	4.0	4.0	4.0	4.0	1.64	.79	.426	.25	.625	1.032	1.977	4.10	10.0	10.0		$\frac{64}{\pi}\,\frac{100}{G}$
ϕ	0	4.0	8.0	12.0	16.0	17.64	18.43	18.86	19.10	19.73	20.76	22.74	26.84	38.84	46.84	$\left(\frac{64}{\pi}\right)\frac{100\,\Delta x}{G}$

Thus, the angles between station 0 and 8, and between station 0 and 14, are:

$$\phi_8 = 19.1\left(\frac{64}{\pi}\,\frac{100\,\Delta x}{G}\right) = 3.98 \times 10^4\left(\frac{\Delta x}{G}\right) \text{ radians}$$

$$\phi_{14} = 46.8\left(\frac{64}{\pi}\,\frac{100\,\Delta x}{G}\right) = 9.54 \times 10^4\left(\frac{\Delta x}{G}\right) \text{ radians}$$

With $G = 11 \times 10^6$ psi as for steel and $\Delta x = 5$ in., corresponding to an over-all shaft length of 70 in., the shaft will twist an amount equal to

$$\phi_8 = (3.89 \times 10^4)\,\frac{5}{11.0 \times 10^6} = .0177 \text{ radians} = 1.02°$$

$$\phi_{14} = (9.54 \times 10^4)\,\frac{5}{11 \times 10^6} = 0.429 \text{ radians} = 2.46°$$

REPRINT of this article can be obtained for your reference file by checking No. E72 on one of the Reader Service cards bound in this issue. For other reprints available see "Current Reprints" listing in this issue on page 139.

EDITOR'S NOTE: To differentiate a curve for a complex equation, try the "Method of Finite Differences," Oct 13, '58, p 77. This numerical method uses a set of equations to give quick approximations.

Another approach to differentiating or integrating a set of points is to find a workable equation that will fit the data; see "Curve Fitting with Orthogonal Polynomials," Apr '56, p 171.

The parts pictured here show that a growing family of plastics is overcoming its "difficult-to-mold" reputation. Here are design ground rules for . . .

BETTER LINEAR POLYETHYLENE MOLDINGS

R B DAVIDSON,
Senior Technical Service Engineer
Applications Lab, Celanese Corp

Linear polyethylene, first introduced as a design material two years ago, has now matured into a family of materials. Like conventional polyethylene, it can be had in a range of densities and melt indexes. However, it behaves differently in the mold. Here, it shrinks differentially because of the semicrystalline structure of the material, and sets up internal stresses that can lead to service cracking. This shrinkage characteristic is often overlooked in design and the resulting trouble has slowed the growth of linear polyethylene as an industrial molding material. Here is a summary of good design practice for this versatile material—a review that shows how to overcome internal stresses and other common molding problems.

MATERIALS

Starting as a 0.960-density material, linear polyethylene is now produced with as low as 0.940 density. The accompanying table shows that higher density materials have greater tensile strength, higher softening temperature, greater stiffness, and higher impact strength. The lower density formulations are superior where environmental stress cracking is a major factor, and are at present special-purpose materials.

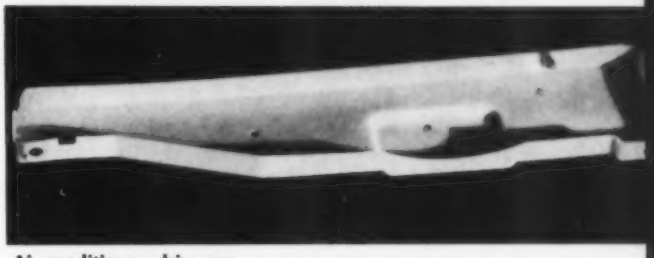
Within each density range is another criterion, the melt index. This is a measure of flow characteristics. The higher index materials are easier to flow; however, those with lower index are superior in resistance to environmental stress cracking, in impact strength, and in low-temperature brittleness.

This brief summary indicates the necessity for compromise when selecting a linear polyethylene. It is usually a three-way compromise involving the structural properties desired, the molding characteristics needed, and economics of the design. Suppliers of these materials can help suggest the best balance in reaching a compromise.

(CONTINUED ON NEXT PAGE)

Floor-waxer tank

Auto-heater duct



Air-conditioner drip pan

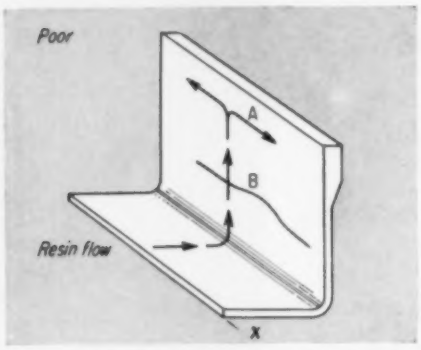
How Density Affects Properties

(For 5.0 melt index)

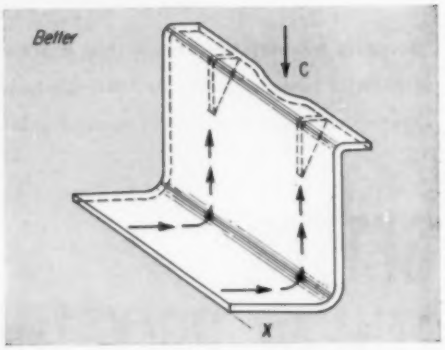
Property	Specific Gravity 0.950	0.960
Heat distortion temp (66 psi), F	175	180
Impact strength, ft-lb/in.	1	3
Tensile strength, psi	3100	3300
Flexure stiffness, psi	100,000	140,000
Stress cracking resistance,* hr	160	3

* Proposed ASTM method for ethylene plastics

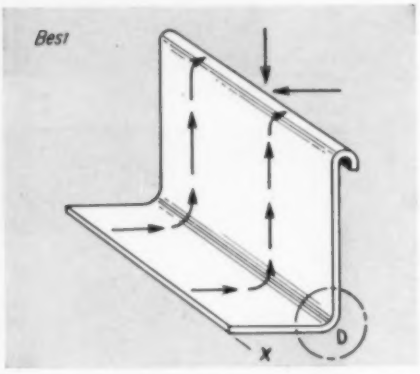
HOW UNIFORM THICKNESS PREVENTS WARPING



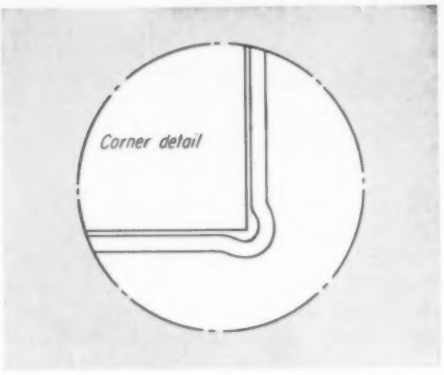
Shrinkage in X-direction at *A* is greater than at *B*, so thinner section at *B* warps under internal compressive stresses.



Shrinkage in X-direction is uniform; however, gussets give only local support. Load at C will bend flange.



Shrinkage in X-direction is uniform, and reverse-curled edge has good stiffness against lateral loads. Inside corner *D* may need special design (right).



Where interior corner must accommodate square-edged components, redesigning at corner, as above, maintains uniform thickness.

DESIGN CONSIDERATIONS

Some of the following design criteria are basic to the molding of any thermoplastic; others derive directly from the special characteritics of linear polyethylenes. All, however, are important when designing industrial parts for these materials:

• **Uniform thickness wherever possible** is a cardinal rule—more so with linear polyethylene than with other thermoplastics—because these materials shrink more in the direction of flow than at right angles to it. Any abrupt increase in thickness may create an easy path for resin to change its flow direction in the mold. The poor flow distribution thus created can often be corrected by improved gating, but the differential shrinkage—and subsequent residual stresses or warping—caused by resin rushing into enlarged areas are harder to control.

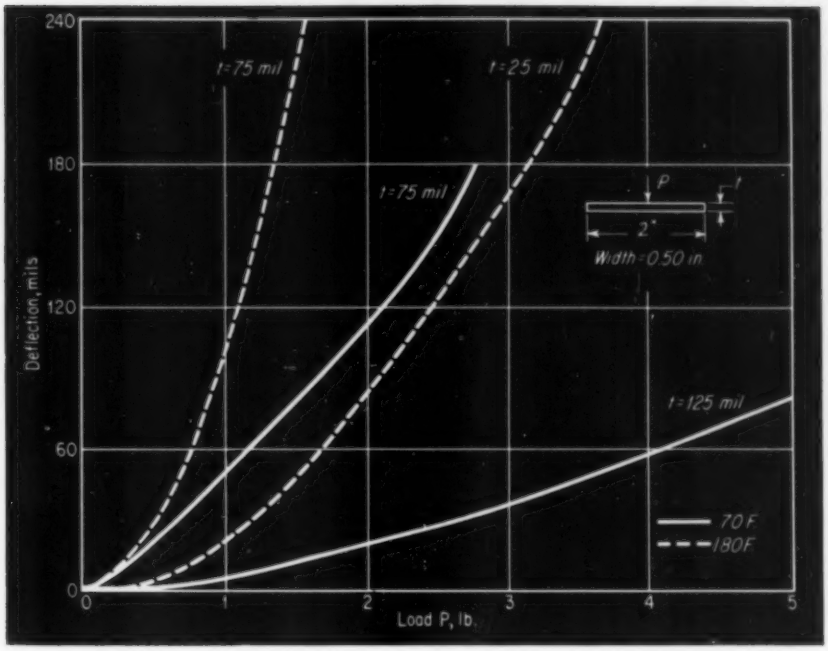
• **Edge reinforcement is particularly necessary at edges of deep-drawn shapes.** Linear polyethylene, while stiffer than conventional, often needs such local stiffness—easily added with the roll-over edge of uniform thickness.

• **Ribs or rolled edges are preferred methods of wall stiffening.** Before increasing wall thickness for added stiffness, check these two techniques carefully. Remember, too: ribs can always be cut into a die later if more stiffness is needed, and mold costs should never be a primary factor in designing the part. A thickness increase all around can make the part uneconomical.

For example: cost of material goes up 24 cents for a simple box 12x12x6 in. deep if ⅛-in. thickness is uniformly increased by 1/32 in. Fabrication costs can jump too: Thicker sections often mean longer mold cycles—giving fewer parts per machine hour, or possibly calling for larger molding machines at a higher hourly rate. Trying sheet samples in various thickness, along with consulting the accompanying flexure curves, will help prevent overdesign.

Tapering ribs to 1° or over will aid release from the mold, and filleting or rounding all corners will reduce residual stress. Rib thickness should be no more than 75% of the wall it supports to prevent sink marks on the surface opposite the rib. To prevent warping, rib placement should not interfere with resin flow in the mold, or permit gross differential shrinkage as discussed previously.

• **Generous radii should be provided,** since sharp corners tend to set up molding strains in linear polyethylene and these often lead to stress cracking. Radii



Load-deflection curves
for 0.960-density linear polyethylene show effect of two thicknesses in flexure at two common design temperatures. Deflections were taken at 15-sec loading intervals, so reflect some creep. Dashed curves show effect of temperature increase from 70 F (solid curves) to 180 F.

should be approximately 50% greater than for styrenes or cellulosics. Also, sharp undercuts should be omitted where possible. Undercuts up to 0.025-in. deep are feasible if corners are rounded.

• **Threads, external or internal, can be molded with all formulations, but should be restricted to the low-melt index materials** because they will resist stress-cracking better when the thread is loaded in use. Since low-index materials flow poorly, local heating may have to be built into the mold at the thread to get desired detail. Molds designed for threaded parts can have unscrewing core pins—either manually or automatically operated—for internal or external threads, or splits for external threads—operated hydraulically or with cams. Rounded threads no deeper than 0.025 in. can be stripped from the mold.

• **Holes are readily molded, but require bosses for reinforcement.** As in all molding design, holes perpendicular to the parting line are best; when parallel, holes require auxiliary mold movement, hence more expensive molds. If bosses are used, round all corners and keep boss height no more than twice the boss diameter. Larger bosses are hard to fill and cause sinking. They also take longer to cool, so can increase production cost.

• **Part draft on deep-drawn shapes should be 5° or more, as design permits.** For shallow parts, 1½ to 2° will suffice. Engraving of any type—raised or depressed—can be reproduced accurately, even on vertical walls. Here, however, wall taper and depth of engraving should be checked for adequate part release. Raised engraving on the part requires less costly molds.

• **Metal inserts can be molded in place.** However, tests are not yet complete on best design practice and materials selection. Investigation to date indicates the lower density linear polyethylenes are probably best choice because they are less sensitive to environmental stress cracking, and shrink somewhat less than the higher density materials.

Physical models are a good way to check appearance, cost and function before expensive molds are constructed. This, combined with testing the first few molded parts prior to use, will catch design mistakes—as well as weaknesses in mold design—before production begins. Oven-aging is a good test for the presence of excessive shrinkage stresses. The part is baked at 240 F for 5 days. If no stress-cracking occurs, projects are good that no service failure due to stress-cracking will occur. When aging at 180 F a 4-5 week observation period is required. At either temperature special chemical environments like detergents can be present if these factors are typical of intended service.

EDITOR'S NOTE: Recent articles on other plastics for industrial molding include the following:

"Three New Tough Rigid Thermoplastics," Sept 29 '58, p 36, compares important properties of Lexan polycarbonate, Delrin acetal and Pro-fax polypropylene resins.

"Additives Strengthen Sintered Nylon," Sept 15 '58, p 86, presents most recent data on latest abrasion-resistant nylon powder mixtures for hot-pressed parts.

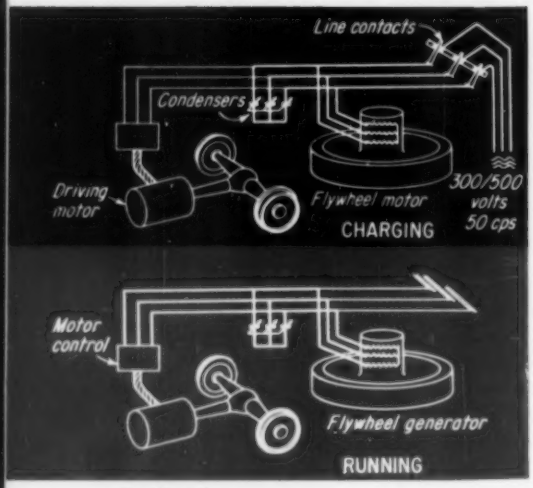
"For Better Phenolic Molded Parts," Sept 1 '58, p 44, reviews basic design principles for a work-horse material.

"Molded Silicone Rubber Parts," Apr 14 '58, p 60, shows how to design best high-temperature performance into parts made with this expensive material.

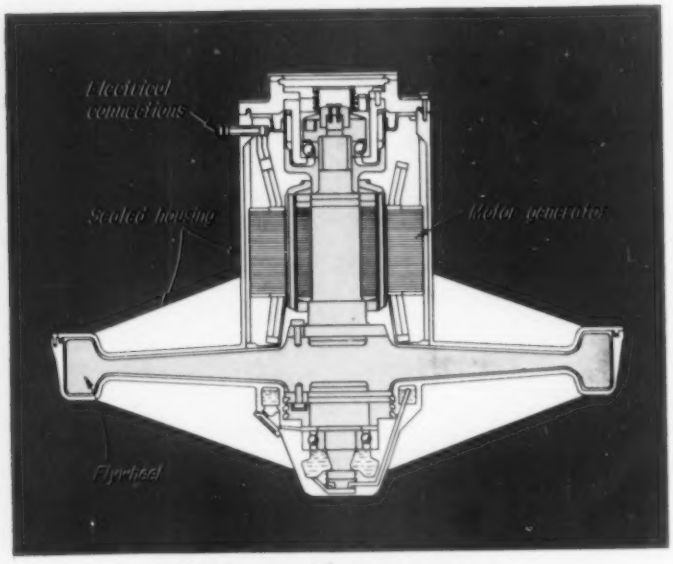
Motor to Flywheel to Generator

Power in this electric locomotive is stored in the flywheel . . . then goes back to the motor-generator . . . where it's turned back into current that powers the drivewheels.

This locomotive, designed for hauling mine cars, gets its actual driving power from squirrelcage motors that deliver 100 hp at 6 speeds. The flywheel shown is 42 in. dia, weighs 5400 lb, can store 6.2 million ft-lb of energy at 1800 rpm. Locomotive weighs 8.5 tons; is 53 in. wide, 11 ft 8 in. long; produces a tractive effort of 3500 lb. It's produced by Oerlikon Engineer-Co, Zurich, Switzerland.



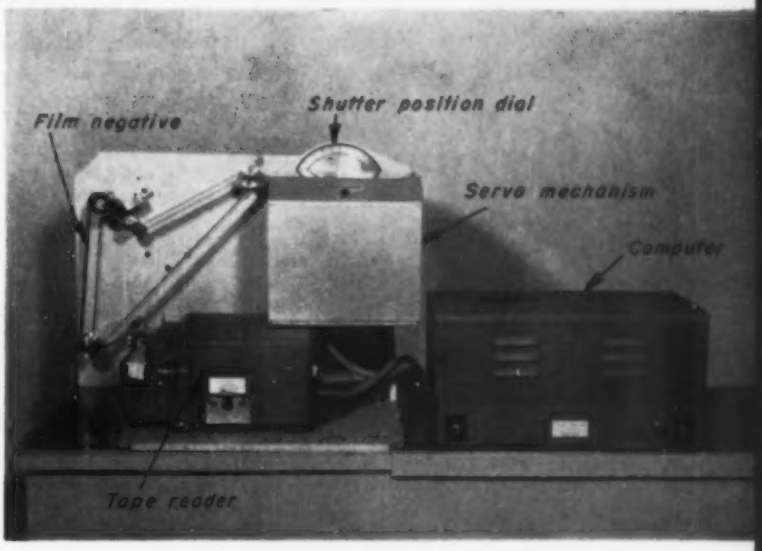
Recharging . . .
the flywheel is accomplished in 30 to 120 seconds, depending on how far the locomotive has travelled since its last stop. Choke coils and capacitors limit motor current to 350 amp and power to 250-300 kw. As soon as recharging is done, the line contacts are opened and the induction motor is self-excited by switching in capacitors. The flywheel motor now operates as generator converting kinetic energy of the flywheel back into electric energy that powers the squirrelcage driving motors. As flywheel speed drops, so does locomotive speed.



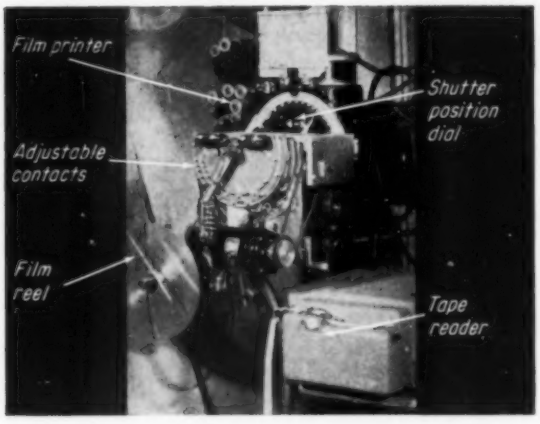
Flywheel and motor-generator . . .
are bolted together, forming a single unit that runs in ball-bearings in a hydrogen-filled casing. Hydrogen at lower than atmospheric pressure, 11 psi, improves cooling and reduces friction losses. When locomotive stops, the flywheel runs idle with very little loss of energy. Based on initial speed of 3000 rpm, it takes 13 hours for the flywheel to run down to a full stop. Regenerative braking returns energy to the flywheel whenever a lower speed range is selected.

Tape reader . . .
plus computer and servomechanism replace manual operation. When printing movie film, light intensities must vary to compensate for differences in amount of light recorded by the camera. Manually, it's done this way: The sequence of light intensities is obtained by visual inspection of the negative and placed on cards to guide the operator. He keeps adjusting the light-selection lever on shutter accordingly.

With Unicorn's automatic method, a keyboard, encoded for required light values, prepares a punched paper tape during visual inspection of the negative. A simple binary system allows five rows of punched holes to store 32 bits of information. The condition of "no holes" is used for rapid tape advance to the first light value. The condition of "five holes" stops the printing operation after the last light value. Remaining 30 points provide an 8-fold light-intensity range of 0.03 log E increments—sufficient for most motion-picture films. Tapes are stored with film negatives for reprint orders.

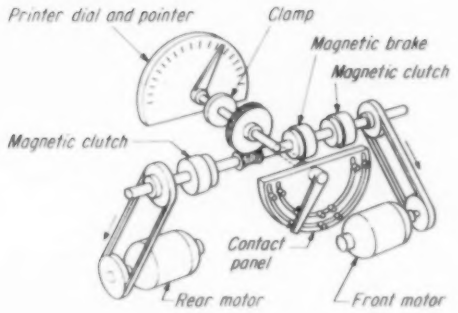


This Light-control Wins an Oscar



Punched tape here works a darkroom auxiliary at automated-production pace. It gives the orders—and a dual-motor drive uses electric clutches to operate the light-control shutter of film printers in the movie industry.

The Unicorn Printer Robot was awarded a technical Oscar by the Academy of Motion Picture Arts and Sciences because it eliminates human error and sharply speeds up processing time. It mounts on standard film-printers without need for mechanical changes on the printing equipment. The unit was developed by Unicorn Engineering Corp, subsidary of Pacific Industries Inc, Los Angeles.



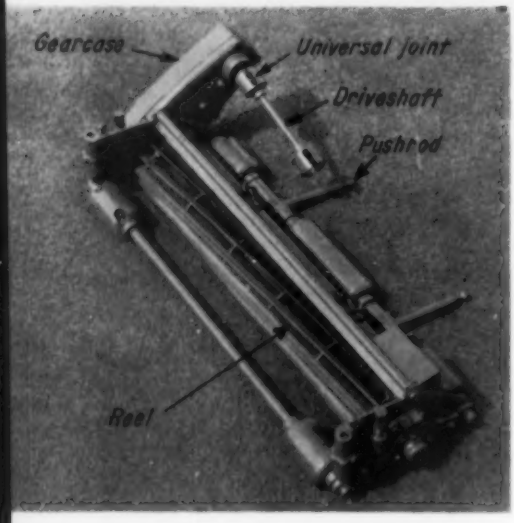
Servomechanism . . .
in photo, left, locks onto printer shutter and positions it for the light value selected by the paper tape. Two motors equipped with shaft-mounted magnetic clutches rotate continuously in opposite directions, driving worm gearing that rotates the shutter pointer to desired position. Drive clutches, and magnetic brake that stops motion of gear train, are located on high-speed side of gearing for rapid movement.

When shutter-control pointer (sketch) reaches required position, the magnetic clutch is disconnected and the magnetic brake energized. Adjustable contacts corresponding to numbered positions on the shutter control are used, in conjunction with a resistive network, to trigger the magnetic brake and disconnect the drive clutches. When the arm reaches its preselected contact, the thyratron tubes powering the clutches are driven to cutoff and the clutch is disengaged. At the same time, current flows through the magnetic brake, preventing further movement of the shutter pointer.

The independent cutter section of this lawn mower is unaffected by engine vibration or operator techinque. Spreading mower weight over seven rollers and two runners reduces ground pressure, protects golf greens.

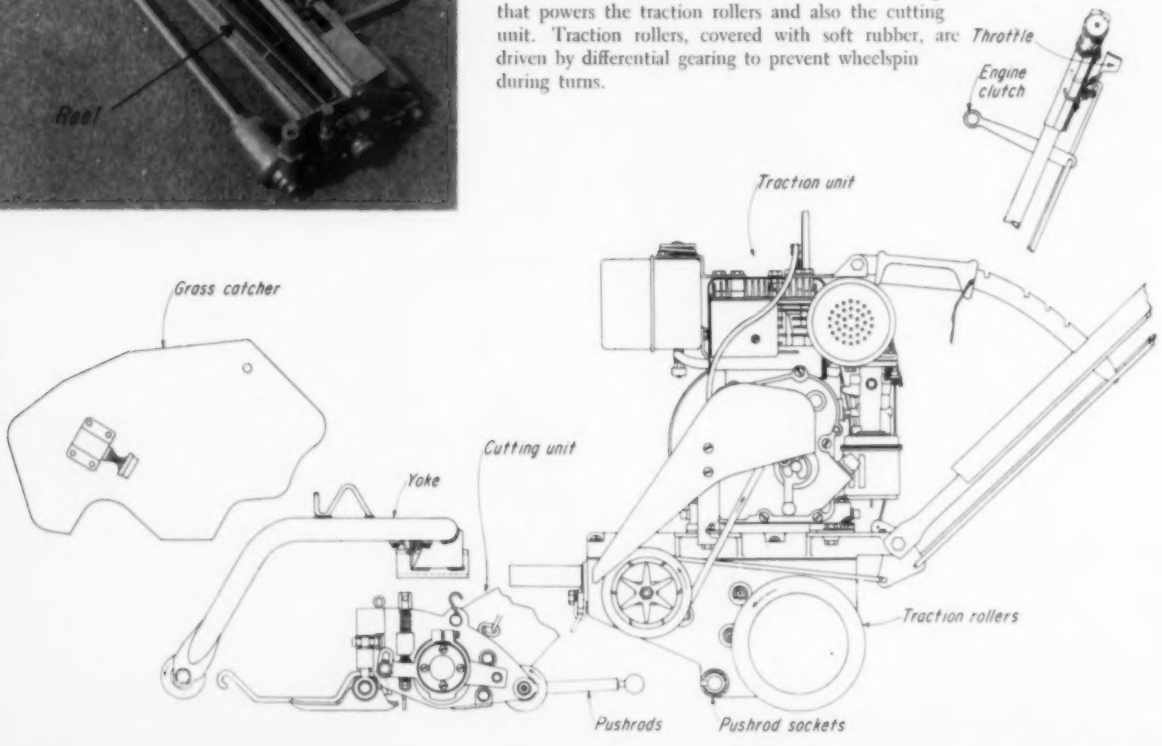
Total weight of mower is 156 lb, yet ground pressure of its heaviest section, the traction unit, is less than one-fifth that produced by a walking man. Ground pressure of this unit is 3.75 psi; ground pressure of a 200-lb man walking is 20 psi. Separate suspension of cutting unit, three rollers and two runners provides a floating action that follows ground contours without gouging or digging in. Designed primarily for golf greens, Greensmaster has maximum cut of 11/16 in. and minimum cut of 5/32 in.; is produced by Toro Mfg Corp, Minneapolis.

FLOATING CUTTER gives grass a fine shave



Cutter and yoke assemblies . . . are pushed ahead of traction unit. Ball-end pushrods at the rear of the cutter snap into spring-loaded sockets on the traction unit. The 3-in.-dia, 12-blade cutter reel is powered by driveshaft connected to traction unit. Ball-pin universal joints at each end of driveshaft provide a flexible connection between traction and cutter units. Yoke slips onto pivot projecting from front of gearcase and is retained by pin. Grass catcher drops into place on yoke.

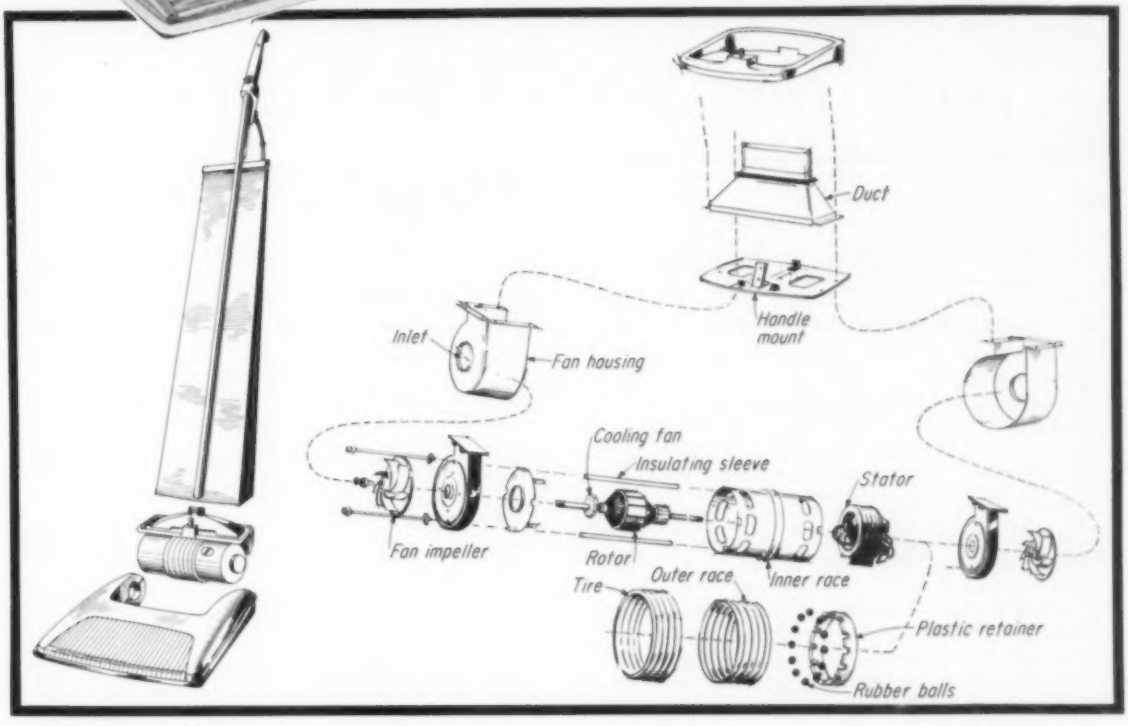
Traction unit is built around cast aluminum gearcase that powers the traction rollers and also the cutting unit. Traction rollers, covered with soft rubber, are driven by differential gearing to prevent wheelspin during turns.



Horizontal Motor for for More Headroom

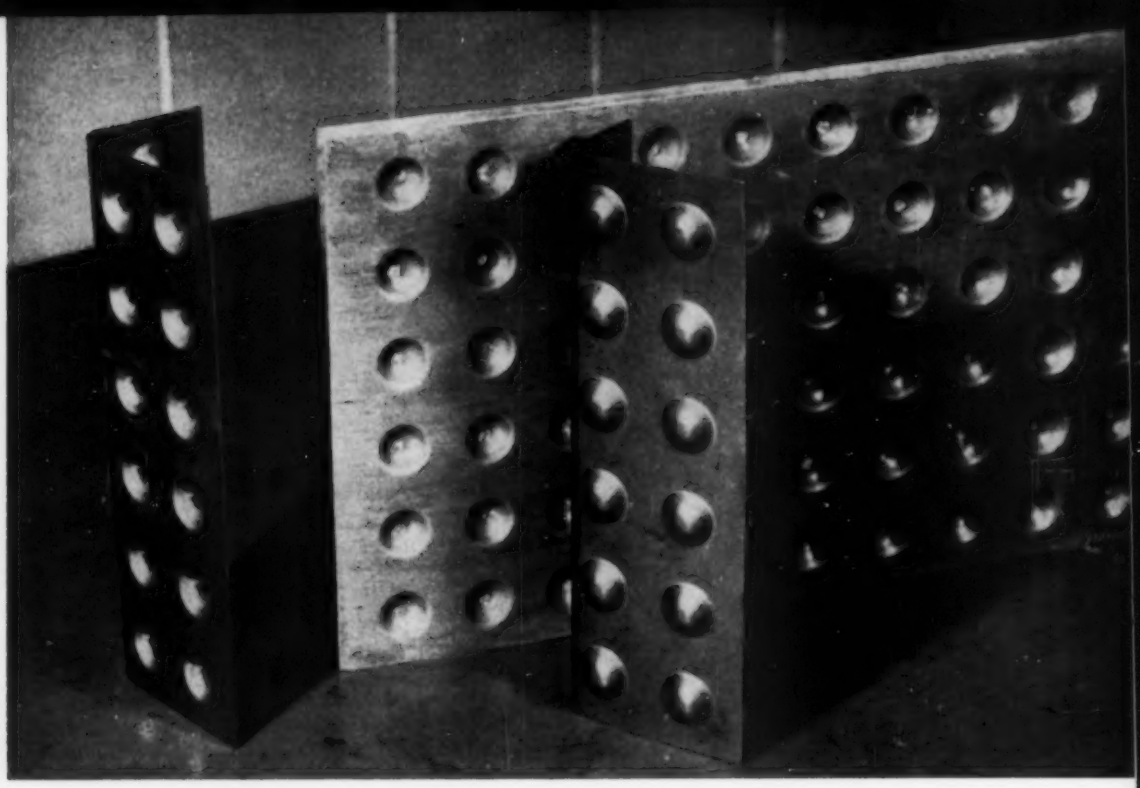
This vacuum cleaner is still an upright model but can get into tighter places. Flipping the motor over on its side reduced height of the base assembly to 4½ in.

Design objective for GE's new cleaner was reduction of height and weight while increasing effectiveness. With the motor shaft horizontal rather than vertical, height of base assembly becomes little more than dia of the motor housing. Using dual fans and smaller dia, high-speed motor (16000 rpm) increased advantage of the horizontal mounting. Roller under the cleaner lets nozzle float on carpet surface, prevents dig-in and scuffing. Extensive use of plastics reduced weight and simplified production by eliminating many finishing operations. Electric cord stores in pocket on dust bag. Twin-Power Model U-1 is produced by General Electric's Vacuum Cleaner Dept, Cleveland.



Basic components . . . of cleaner are its nozzle assembly, motor assembly, and handle. Motor assembly is mounted with an impeller at either end of the shaft. The handle is rigidly mounted on the motor and can rotate with the motor 105°. This results in a floating nozzle, permits handle to be lowered to the floor, also allows storing the cleaner by hanging it flat against the wall.

Exploded view of the motor assembly and wheel-and-roller assembly shows construction details. Wheel runs on ballbearing using hard rubber balls and a plastic retainer. Groove in motor housing forms inner race and outer race provides rim for vinyl tire. Rubber balls provide silent operation and do not bind on lint or dust. Motor has internal cooling fan, uses sealed ballbearings and nylon insulation. Extended armature shaft accommodates twin impellers.



meet the "INSECT-WING" Metal Panel

Butterfly wing cross section

Butterflies Gave the Clue

Research on low-weight, high-rigidity panels in prewar Germany led the author to examine butterfly wing structures as a source of design ideas. His joint studies with entomologist Erich Mueller led to methods of cleanly cutting the insect wings for examination, and to a certain species of butterfly, from India, whose wing span-to-thickness ratio was 160:1 (aircraft wing design at that time had only reached a ratio of about 11:1). Shown is typical cross-section that formed basis of dimpling-and-welding technique described in this article.

Although the war impeded development of manufacturing equipment for the newly designed metal panels, they were used in limited quantities in several products: ramp-type front and rear walls of railroad cars to simplify unloading of military vehicles, transportation crates weighing but 10% of load capacity, and cores for cable rolls to replace wood and lighten shipping weight.

Currently the Argentine metallurgical combine, Tadema SRL, Buenos Aires, is preparing large-scale manufacture of twin-sheet panels up to 240 cm wide. Export quantities may be available as early as Sep 1959 (manufacture in the US, under license, may also be underway by then).

A German engineer . . . plus an entomologist with his special butterfly from India . . . then the needs of war . . . now Argentine technology gets into the act . . . and we present this latest technique in construction of twin-sheet panels. Their rigidity and light weight come from dimples and spot welds.

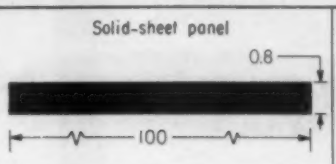
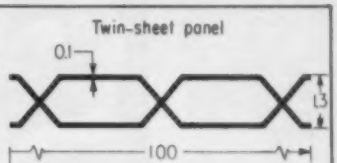
Dr W M VON TANNENBERG, Tadema, SRL Buenos Aires

A simple, economical structural-panel design has been developed to compete with twin-sheet metal structures built by such other techniques as waffle-beading, sandwiching, or lattice-bridging. Imitating the structural design of insect wings, the new steel panel takes only 30 lb of steel to give the same bending resistance as 120 lb of solid sheet. And on a pound-for-pound basis with other inexpensive light-construction elements, it will support nearly 20% more flexural loading.

How It's Made

A hydraulic press simultaneously dimples the two faces that will form the panel. This is done by pressing two pre-cut steel sheets, or carefully indexed lengths of coiled stock, against a common central beam which carries an interchangeable bead mold with pattern on top and bot-

STIFFNESS COMPARISON

Cross-section dimensions, cm	Solid-sheet panel 	Twin-sheet panel 
Weight, kg./m^2 lb./ft^2	63.5 13	63.5 13
Moment of inertia, cm^4 in.^{4}	4.3 0.1	7.2 0.17
Section modulus, cm^3 in.^{3}	10.7 0.65	18.0 1.1

tom. The dimples are pressed with flat bottoms. After the necessary number of forming strokes, the matched pair of sheets are brought together automatically and passed to a multiple-head resistance welder for spot-welding where the dimples meet.

Present equipment turns out twin-sheet panels at 1 to 2½ yd per min. The lower rates apply to sheet thicknesses over 3 mm which require preheating. Dipping in rust-inhibiting primer, then oven-drying, complete the cycle.

How It Performs

Most "insect-wing" panel construction to date has been with ordinary hot-rolled carbon steel 1 to 3 mm thick, though during World War II German bridges were repaired with panels of 8-mm stock. Bending section modulus depends on panel thickness H and sheet spacing H_o, and can be approximated from the following equation for a beam of width B:

$$Z = \frac{1}{6}\left(\frac{B}{H}\right)(H^3 - H_o^3)$$

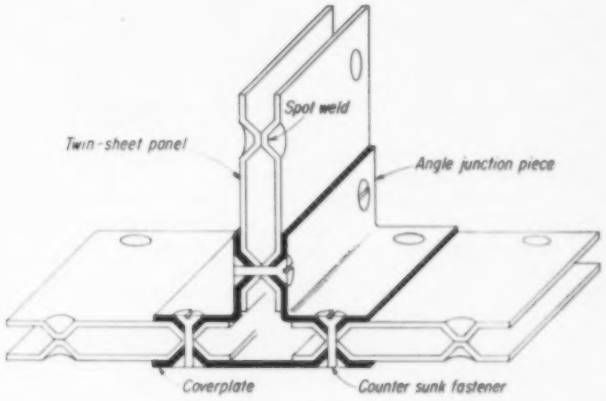
To compute the weight per unit span length of a twin-sheet panel made from material of thickness t, that will give the same bending stiffness as a solid sheet of unit weight w and thickness h, the following approximation applies:

$$W = \frac{2\,thH}{(H^3 - H_o^3)}\,w$$

By placing the spot welds midway between the faces, at the neutral axis, the joint holding the structure together is taken out of the area of maximum bending stress. Even though maximum beam shear occurs at this midway location, its value is only a small fraction of maximum bending stress—except in some beam designs where applied load and reactances may be close together and shear loads high.

When Assembling

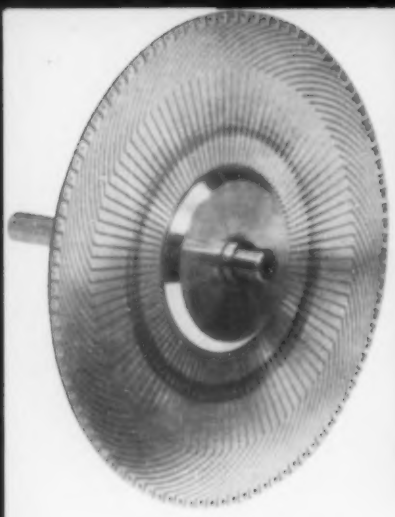
Coverplates are used to join one panel to another. Made from sheet stock with slightly smaller dimples, these junction pieces can be brake-formed into special angle forms. Then panels can be joined to form corners, T-profiles and X-profiles (see sketch) to fit design needs.

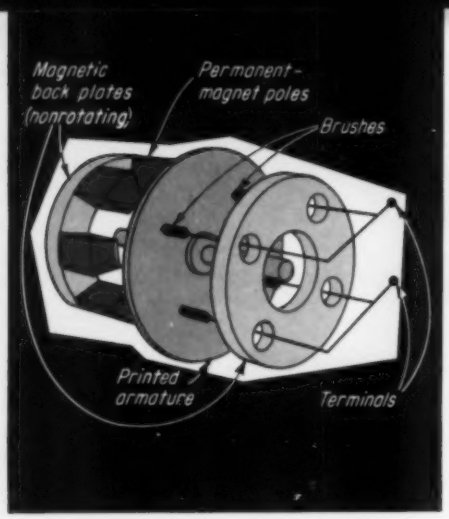


Typical T-joint

Standard junction pieces are designed the same thickness as the panel, except when unusually high loads occur at the junction. Where concentrated loads come between junctions, as in railroad car and truck bodies, a coverplate should be added for reinforcement. Here, coverage over 6 to 16 dimples is usually required. Countersunk threaded fasteners are used for all junctions and reinforcements, though rivets are feasible. Countersunk screws apply where panels are joined to wood.

EDITOR'S NOTE: The following articles present detailed design information on other techniques of panel stiffening: "15 Plate-stiffening Compared," July 21 '58, p. 82, summarizes recent German data showing strength differences among various designs of stiffened sheet-metal plates; for a guide to sandwich-panel materials selection, refer to a recent three-part series—"Cores," Jan 20 '58, p 70; "Facings," Apr 28 '58, p 80; "Adhesives," May 26 '58, p 56. "Beading Techniques," July '55, p 183, and "Waffle Beading", Aug '55, p. 171 give design criteria for stiffening sheetmetal panels.





now you can PRINTED-

THIS EXAMPLE IS YOUR GUIDE

■ Suppose you want to design a ¼-hp printed-circuit dc motor that will run at 1800 rpm off a 32-volt supply. The data needed will be found in the Motor Design Chart and the list of Similitude Relationships which provides basis for the chart. This chart gives two characteristic curves—from which disk size can be estimated for a variety of motors within confines of the given design conditions.

Essence of the method is this: (1) It calculates a hypothetical motor with the required power, and later makes adjustments for the actual speed and terminal voltage desired; (2) Terminal voltage, less brush drop of 1 v, is proportional to number of printed conductors per side of disk for a given disk size. Deviation of this calculated voltage from the assumed supply value will require varying the number of conductors according to similitude relations.

In design, permanent-magnet poles can be any even number: 6 or 8 are recommended. This example selects 8 because they add up to slightly lower weight for same power output.

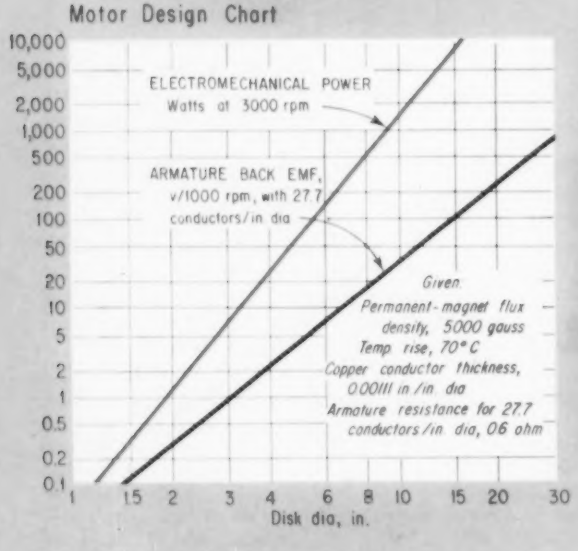
The chart gives a plot of *EMP*, the total electromechanical power developed in the armature. This wattage, less windage and other mechanical losses (totalling about 10%), gives rated output.

Step 1—Armature power, *EMP*. Rated output for the desired 1800-rpm motor is about 375 w. But the chart is for a 3000-rpm motor, so first convert to 3000 rpm: $375 \times (3000/1800) = 625$ w. Now, add about 75 w for mechanical losses and EMP = $625 + 75 = 700$ w.

Step 2—Disk diameter. Power curve on the chart shows that a disk of 8.6 in. dia is needed for EMP = 700 w.

Step 3—Number of conductors, *N*. Hypothetical motor has 27.7 conductors/in. dia; $N = 27.7 \times 8.6 = 238$ conductors.

Step 4—Back emf, E_A. EMF curve gives 20-v back emf per 1000 rpm for a 8.6 in.-dia disk with 238 conductors. Total back emf $E_A = (1800/1000) \times 20 = 36$ v.



Similitude Relations

For printed motors of all sizes, performance is easily predicted from known performance of one given size, if every physical dimension is scaled in the same proportion as the armature diameter D. Field flux density, motor temperature rise, and number of conductors per inch diameter, are assumed constant in applying the chart. The method is based on these similitudes:

Torque at constant rpm $\propto D^{3.5}$

Terminal voltage and back emf $\propto D^2$

Efficiency $\propto D$ ***(approx.)***

Mechanical time constant for given design is constant for any value for D.

Armature resistance stays constant for constant number of conductors per in. dia

Weight/hp at constant rpm $\propto 1/D$

If conductors per in. dia varies, then armature resistance for given dia varies as square of number of conductors.

design your own DC Motors with

CIRCUIT ROTORS

You had a first peek, in our Feb 16 issue, at this truly revolutionary concept in motor construction. Now we show how to draw up specifications for these motors that weigh less and cost less but offer competitive performance.

R PAGE BURR, *president*
Circuit Research Co, Cold Spring Harbor, NY

R L SWIGGETT, *exec vice-president*
Photocircuits Corp, Glen Cove, NY

Step 5—Armature current, I_A. Calculate for desired motor as follows: EMP = (1800/3000) × 700 or 420 w. I_A = EMP/E_A = 420/36 = approx 11.6 amp.

Step 6—Armature resistance, R_A. The similitudes show that armature resistance (measured from terminal to terminal, less brush resistance) will stay constant if copper thickness as well as number of armature conductors varies directly with diameter of disk. Resistance for 27.7 conductors/in. dia is 0.6 ohm.

Step 7—Armature voltage drop, I_AR_A. 11.6 × 0.6 = about 7 v.

Step 8—Terminal voltage, E_T (for 238-conductor motor). E_T = $I_AR_A + E_A + 1$ v (for brush) = 7 + 36 + 1 = 44 v. This is larger than the 32 v available, therefore the number of armature conductors must be decreased.

Step 9—Ideal number of armature conductors. $N = 238 \times (32 - 1)/(44 - 1) = 171$.

Step 10—Compromise for practical manufacture. Final N must relate to number of poles as follows:

6 poles, $N = 3n + 1$
8 poles, $N = 3n + 1$

where n is any integer. Value n here for 8 poles will be 42, so that $N = 4 \times 42 + 1$, or 169 conductors.

Step 11—Copper thickness for 8.6-in.-dia disk. 8.6 × 0.00111 = 0.0095 in.

Step 12—Efficiency. This is independent of N unless E_A and N become very small. Therefore calculate from data on 238-conductor motor.

Output = 375 w. EMP = 420 w. Input = $E_T \times I_A$ = 44 × 11.6 = 510 w. Efficiency = output/input = 375/510 = 73.5%.

Step 13—Performance of desired motor. Terminal voltage corrected for 169-armature conductor is $E_T = 1 + (169/238)(44 - 1) = 31.5$ v, where 1 is brush drop. Armature current I_A = (238/169) × 11.6 = 16.3 amp. Armature resistance for 169 conductors, by similitude, is about 0.6 $(169/238)^2$ = 0.3 ohm. Armature loss $I^2_AR_A = (16.3)^2(0.3) = 80$ watts. Input power $E_TI_A = 31.5 \times 16.3 = 510$ watts. (This input value is same as for Step 12 because efficiencies and output were assumed to be identical.) ■

For a radically new idea in motor construction, look at the photo on opposite page. **The disk you see is a rotor—no iron core and conventional windings.** And the sketch shows how simply it assembles with the stator.

Such rotors mark a milestone . . . the advantages of printed circuits can now be built into dc motors. These are custom-built motors that have a printed-circuit armature. It is the disk you see—a flat, lightweight base of insulating material, with copper conductors bonded so firmly to each face that they will withstand high rotational speeds.

Such motors, pancake-shape because of the disk, are easy to make because **they need no bulky windings, laminations or insulation for either the armature or field. Only the terminals require insulation.** Without insulation placing a limit on operating temperature, the disk can be made of glass or ceramic materials. Disks are supplied under a licensing arrangement, either for a single motor or for mass production.

There is no limit to power output of such motors. Armature ratings from 1/200 to 4 hp are already available and an armature for a 200-hp motor is being developed.

In all sizes except the smallest (below 1/25 hp) the motors give equal or better performance—and with less weight, lower cost and fewer parts—than the conventional wound-rotor dc types. The same simplicity should reduce enclosure problems. Enclosures can be of any type meeting NEMA standards.

The main tools needed for specifi-

cations are supplied with the example accompanying this article. One is a Motor Design Chart—it plots the key relationships for a typical set of conditions. The other is a set of similitude relationships—with them, performance of other sizes can be predicted from the known performance of a given size.

Each completed motor has four simple, basic parts: a permanent-magnet field assembly; the rotor disk; a set of commutator brushes that ride directly on the armature conductors; and a simple shaft with bearings.

Weight and inertia of the disk is very low compared with wound rotors of same current capacity. This is because **the armature contains no iron, is only thick enough for rigidity, and has no conductor insulation.**

It gives good heat dissipation—via pole pieces to the motor frame. Armature current densities up to 30 or 40 amp/sq mm continuous or 100 amp/sq mm intermittent are permissible. These values are many times greater than is feasible with wound rotors.

There is virtually no cogging at any speed. Smooth operation results from the large number of armature conductors and because magnetic field is not disturbed by rotating armature. Electrical impedance is low, giving suitability for operation with power transistors. And electrical losses at stall or low-speed conditions are less with the permanent-magnet field poles than with conventional wound poles.

For Specific Designs

The example accompanying this article is for a simple motor application. Design will usually require the consideration of several additional variables.

Variable-speed motor operation is obtained by controlling input voltage. The advantages of low electrical losses at stall, and of smooth commutation suggest applications for machine-tool drives and for torque motors.

A damped-motor design for servo applications is simple. Here, aluminum instead of a nonconducting material can be chosen for the disk base. Eddy currents provide braking proportional to speed, and torque output becomes zero at very low rpm—about 160. Full starting torque is available until the disk starts to move. Final speed is less, and is therefore reached more quickly than for non-damped disk.

For servomotors, pulse motors, and high-response motors, the desired mechanical time constant and theoretical acceleration must be taken into account. For most printed motors, the mechanical time constant lies in a range between 10 and 50 millisec. Some special-purpose motors such as the damped motor can have time constants lower than 4 millisec. The theoretical acceleration of a 3.6-in. dia motor is about 23,000 radians/sec^2. But these variables are dependent on the copper thickness and magnetic field structures.

Combination motors and generators, with various types of ac and dc operation within a single structure, can be designed by adding sliprings to the dc armature windings. Commutation is not troublesome and there is no iron in the armature to increase losses and produce sparking Therefore speed need not be a limiting factor on combination machines such as high-frequency dc-to-ac and ac-to-dc converters. Where necessary, independent armature circuits may be printed on the same disk. And the permanent-magnet field can be replaced by a laminated iron core with a bobbin winding to give universal motor operation.

The Limitations

The pancake shape of a printed motor is somewhat unconventional and may require new thinking for mechanical design of products. The smallest practical diameter of a printed disk, limited by closeness of the conductors, is about 2 in. And the motor is primarily a low-voltage device because of the practical limit in total number of conductors. A recommended range is from 13.85 to 27.7 conductors per in. dia.

The airgap is inherently larger than that of conventional dc motors, and higher magnetizing forces are required. The greater gap is needed because acceleration forces and gyroscopic action will deflect a disk more readily than they will bend a conventional rotor, and both flatness and close clearance are more difficult to achieve.

Maintenance is not a problem, but requires different planning. It is economical and necessary to stock spare disks for quick field replacement because of difficulty in repairing the thin, precise conductors.

REPRINT of this article can be obtained for your reference file by checking E71 on one of the Reader Service cards bound in this issue. For further reprints available see "Current Reprints" listing this issue or page 139.

EDITOR'S NOTE: In these last few years we have covered the field with several dozen articles on motors of all types from 1/200 to 4000 hp. A complete bibliography of these articles appeared recently: "Here's Help in Selecting the Right Motor," Oct 13 '58, p 86.

For a complete analysis of all fhp motors and how to choose between them, see "Which Fhp Motor for the Job?" Jan 19 '59, p 76. Salient mechanical features and test methods were discussed in "Check These Features Before Applying Your Fhp Motor," Dec. 22 '58, p 60.

About the Invention

The printed-circuit motor was invented by J. Henry-Baudot and F. H. Raymond of SEA (Societe de l'Electronique et d'Automatisme), a French company. Printed Motors Inc, 30 Rockefeller Plaza, New York City, introduced the invention in the USA; Photocircuits Corp, Glen Cove, NY, perfected the circuit-printing techniques and made the first practical printed armatures. Circuit Research Co developed the electrical circuits and built the first prototype motors in this country. Photocircuits Corp advises that a license will be required for any company wishing to manufacture these motors.

CIRCLE 130 READER SERVICE CARD→

Again Eastman leads the way in color—

with 8 TENITE POLYETHYLENE

Standard Color Concentrates

60704 BLUE

60706 LIGHT YELLOW

60703 GREEN

60702 TURQUOISE

60701 PINK

60707 BRIGHT YELLOW

60700 WHITE

Advantages: Use of messy dry colorants is eliminated • Color uncertainty and contamination possibilities are minimized Easier and faster color changes are possible • Mixing time is reduced • Inexpensive mixer hoppers can be used

Tenite Polyethylene *Standard* Color Concentrates offer molders a quick, clean and sure means to color polyethylene for injection molding or continuous extrusion. The cost is usually less than a penny a pound when used in a 1-10 ratio with natural material. Lighter or darker shades, of course, can be obtained by varying this ratio. Also, by combining concentrates of different colors in ratios determined by experimentation, other attractive colors may be produced.

Because these concentrates consist of natural polyethylene resin in which coloring agents have been thoroughly predispersed, pigment agglomeration is virtually eliminated. The result: excellent, uniform dispersion of the color throughout the molded product.

Standard color concentrates are stocked for immediate shipment in 50-pound multiwall bags and in 10-pound polyethylene bags. Other concentrates are also available (at slightly higher cost) in an almost unlimited range of colors to satisfy any color request.

To color polyethylene .....

...add Tenite Color Concentrates

TENITE
POLYETHYLENE
an Eastman plastic

For prices and a set of molded 1-to-10 samples of our eight standard colors, write EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

The big advantages of Taper-Lock mounting are now available for practically all of your sprocket installations. Below is listed the new wide range of types and sizes offered by Dodge!

This important expansion of the Dodge line is the result of the enormous popularity of the Taper-Lock idea. Taper-Lock Sprockets are *modern*. Industry likes them because they go straight from shelf to shaft without machining—saving time. They are "easy on—easy off"—saving work. Their bushings can be re-used, not only in replacement sprockets, but in sprockets of different sizes and also in Taper-Lock Sheaves, Couplings, Conveyor Pulleys. Taper-Lock saves inventory—and money!

Dodge Taper-Lock Sprockets and Dodge Roller Chain are available through your local Dodge Distributor. Call him. Or write us for bulletin.

TAPER-LOCK®

ROLLER CHAIN DRIVES ARE NOW AVAILABLE IN A NEW WIDE RANGE OF TYPES AND SIZES

No Reboring!
No Keyseating!
No Waiting!

DODGE
of Mishawaka, Ind.

CALL THE TRANSMISSIONEER — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

- ***DOUBLE PITCH CHAIN and SPROCKETS***
  Transmission Series (No. 2040 to 2080) and Conveyor Series (No. 2040 to 2100). Sprockets to 112 teeth—including, for the first time, stock sprockets of 17, 19, 21, 23, 25 and 35 teeth *made especially for double pitch chain*. Introduced by Dodge, these sprockets are designed for even distribution of tooth engagement and absolute accuracy of mesh. Wear is reduced by half. Life of chain and sprocket is doubled!
- ***PLATE SPROCKETS***
  Steel Plate, Type A. No. 35 to 120. Mandrel bore, bored-to-size or Taper-Lock.
- ***SINGLE STRAND CHAIN and SPROCKETS***
  No. 35 to 160. Sprockets to 112 teeth.
- ***DOUBLE STRAND CHAIN and SPROCKETS***
  No. 35-2 to 80-2. Sprockets to 112 teeth.
- ***STANDARD ATTACHMENTS***

ALL TO ASA STANDARDS

DODGE MANUFACTURING CORPORATION, 1200 Union Street, Mishawaka, Indiana

NEW HYDRAULIC FLOW CONTROL VALVE

Calibrated for Precision Control

3/8" VALVE
Actual Size
$16.00

HANNA *Flo-Set 1000* VALVES

are used for controlling flow of petroleum liquids, water and synthetic hydraulic fluids.
Pressure to 1000 psi.
Sizes ¼", ⅜", ½" and ¾"
Temperatures –40° F to +250° F

To meet the demands for precision control of hydraulically powered equipment, Hanna offers this new calibrated speed control valve. Flow can be accurately regulated from zero to desired rate by turning the adjusting sleeve. Once set to the desired flow rate the valve can be "locked". Calibrations assist in setting the valve to pre-determined flow rates.

The new Flo-Set 1000 Valves are the result of over 50 years of Hanna design and manufacturing experience in the field of fluid power. They are built to close tolerances with quality materials and like all Hanna products they are offered only after extensive laboratory testing and field experience. Their performance is guaranteed for the service specified.

Ask your Hanna Representative listed in your classified directory and Thomas' Register for complete information—or write us for details.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES

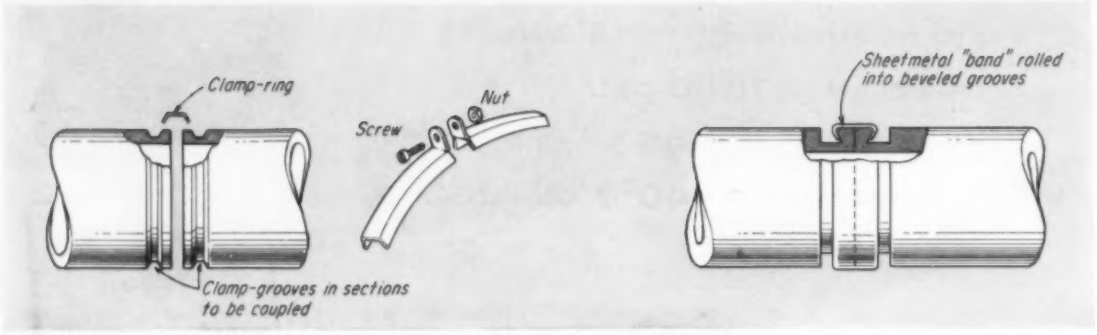
1763 ELSTON AVENUE, CHICAGO 22, ILLINOIS

11 ways to COUPLE TUBES

An assortment of mechanical joints, including clamps, screws, threaded and welded sleeves

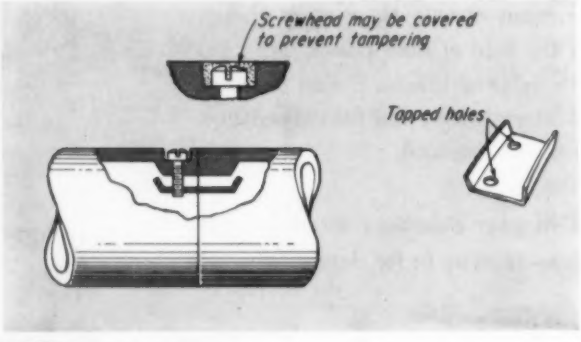
FRANK WILLIAM WOOD JR, *Design Engineer, Vitro Laboratories, Silver Springs, Md.*

CLAMPS . . .



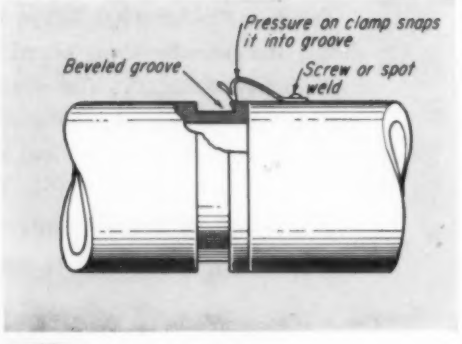
1 2

External clamp-rings . . .
fitted into channels do not project above exterior surface of tube, except for fastening lug (1). Machine assembly is necessary in rolled-band method (2) and joint cannot easily be disassembled.



3

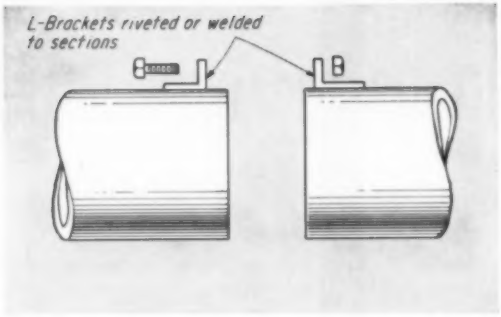
Internal U-clamp . . .
also provides flush exterior, may be either split ring or series of single clips. Only one screw need be used for light-duty applications.



4

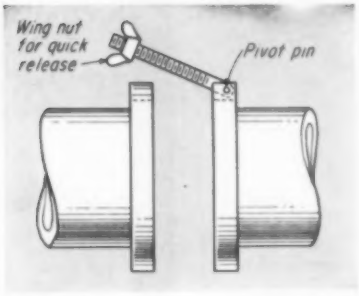
Snap clamp . . .
provides quick release and requires no tools to fasten or release, but is limited to relatively light loading conditions unless multiple clamps are used.

SCREWS . . .



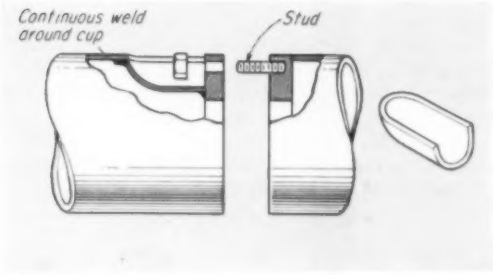
5

L-Brackets . . .
project from exterior surface—where this is not objectionable they provide simple, firm coupling.



6

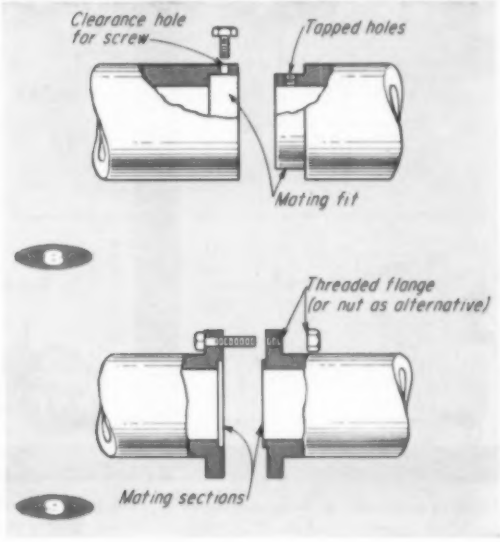
Pivoting screw . . .
and wing nut give quick-release coupling —and are strong enough to withstand relatively heavy forces, depending upon number of screws used.



7

Cups welded . . .
in place permit tube or cylinders to withstand internal gas or liquid pressure, yet still have flush exterior.

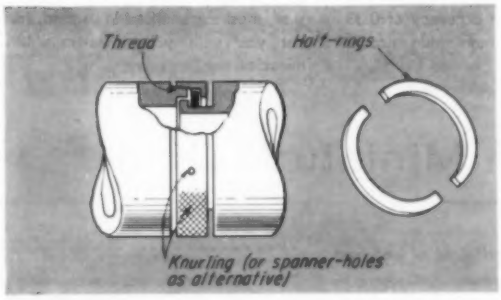
Mating ends . . .
allow tube lengths to be assembled for trial positioning before fastening more permanently with screw. In (8), screw is in shear; in (9), flange is in shear.



8

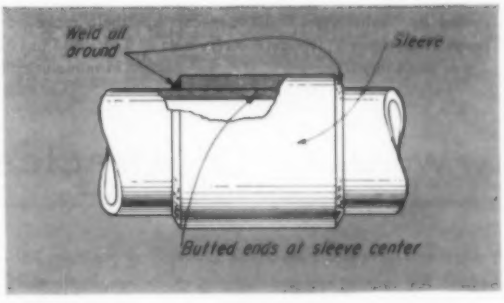
9

SLEEVES . . .



10

Threaded sleeve . . .
provides clean-looking, easily separated joint. If half-rings are used to ensure even clamping, joint will not be leak-tight (closely butted ring-ends will help reduce leakage).



11

Welded sleeve . . .
makes permanent, leak-proof coupling. However, if joint need not be leak-proof, tack-welding will provide high-strength coupling. It also makes a good emergency coupling.

Miniature Soldiers. Army ants carry out intricate maneuvers of wheeling, flanking, and envelopment with faultless precision. Their columns are led by "majors", preceded by "scouts". Raids are conducted by "skirmishers". Between campaigns, they form "bivouacs". Army ants are nature's tiny troopers.

Miniature Ball Resolver, approximately 3⅜" x 2½" O.D. continuously calculates position of aircraft and missiles traveling at supersonic speeds. MPB bearings at critical points keep torque low, and help make possible an accuracy of 0.33 of 1%. This is another man-made miracle in miniaturization.

Man with Miracles. This is Jim Mitchell, one of MPB's technical representatives, whose close liaison with the manufacturer of the ball resolver facilitated its design and development. MPB's technical staff, most experienced in its field, can assist you with your own miniaturized miracles.

New Worlds for ○ Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN BALL RESOLVER SHOWN ABOVE

Every day man's advances, both on this planet and beyond, are opening new and challenging areas of application for miniature components and mechanisms. And at each step forward, MPB is ready to help with research, engineering and manufacturing facilities unsurpassed in the miniature bearing industry. MPB makes more than 500 types and sizes of bearings ranging from ⅜" O.D. down . . . designed to meet requirements of the most exacting nature. Specials are developed on request. For a confab on design problems or our latest catalog **write Miniature Precision Bearings, Inc.,** 203 Precision Park, Keene, N. H.

MINIATURE PRECISION

MPB

BEARINGS, INC.

Helps you perform miracles in miniaturization

formulas and curves give quick answers for

PARTIALLY LOADED CONTINUOUS BEAMS

ALEXANDER KRIVETSKY, *Bell Aircraft Corp, Buffalo*

Problems of partially loaded, continuous beams are usually tough to analyze and tedious to calculate. The formulas and curves given here remove the headaches and hard work from many such problems.

The 3-moment equation for a constant-section, continuous beam on level, rigid supports—the most usual case—can become:

$$\frac{M_1L_1}{I_1} + \frac{2\,M_2L_1}{I_1} + \frac{2\,M_2L_2}{I_2} + \frac{M_3L_2}{I_2} = f\,(w_1, L_1, I_1) + f\,(w_2, L_2, I_2)$$

The right-hand side of the equation differs with each different loading or loading combination. Formulas for 10 different loadings are tabulated below; curves on the continuing page speed answers to these formulas. To solve any 3-moment equation for a continuous beam with spans loaded as illustrated in table:

1. Select appropriate formula
2. Find value of loading coefficient from curves
3. Substitute numerical values L, w, and loading coefficients in the above equation. (There will be as many equations as there are indeterminate moments, e.g. a 2-span continuous beam will require a simultaneous equation with two unknowns.)

Sign conventions for the equations are: Positive moments cause compression in upper fiber; positive loads act upwards.

Symbols

I_1 = moment of inertia of left-hand span
I_2 = moment of inertia of right-hand span
L = span length in general, in.
L_1 = Left-hand span length, in.
L_2 = right-hand span length, in.
M_1, M_2, M_3 = moments at three consecutive supports
m, k = load-location/span-length ratios
w = distributed loading, lb/in. (cases 2 to 10) or concentrated load, lb (case 1 only)

Loading Formulas

(Left-hand span only is shown; right-hand span is a mirror image. Loading coefficients are in square brackets.)

1. $\frac{wL^2}{I}\left[k - k^3\right]$

2. $\frac{wL^3}{I}\left[\frac{k^2}{2} - \frac{k^4}{4}\right]$

3. $\frac{wL^3}{I}\left[\frac{1}{4} - \frac{k^2}{2} + \frac{k^4}{4}\right]$

4. $\frac{wL^3}{I}\left[\left(\frac{m^2}{2} - \frac{m^4}{4}\right) - \left(\frac{k^2}{2} - \frac{k^4}{4}\right)\right]$

5. $\frac{wL^3}{I}\left[\frac{k^2}{3} - \frac{k^4}{5}\right]$

6. $\frac{wL^3}{I}\left[\frac{k^2}{6} - \frac{k^4}{20}\right]$

7. $\frac{wL^3}{I(1-k)}\left[\frac{2}{15} - \frac{k}{4} + \frac{k^3}{6} - \frac{k^5}{20}\right]$

8. $\frac{wL^3}{I(1-k)}\left[\frac{7}{60} - \frac{k^2}{2} + \frac{k^3}{3} + \frac{k^4}{4} - \frac{k^5}{5}\right]$

9. $\frac{wL^3}{I}\left[\left(\frac{m^2}{3} - \frac{m^4}{5}\right) - \left(\frac{k^2}{6} - \frac{k^4}{20}\right) - \left(\frac{km}{6} - \frac{km^3 + k^2m^2 + k^3m}{20}\right)\right]$

10. $\frac{wL^3}{I}\left[\left(\frac{m^2}{6} - \frac{m^4}{20}\right) - \left(\frac{k^2}{5} - \frac{k^4}{5}\right) + \left(\frac{km}{6} - \frac{km^3 + k^2m^2 + k^3m}{20}\right)\right]$

(CONTINUED ON PAGE 75)

PowerGrip FLEXIBLE COUPLING

GEARED FOR TOP EFFICIENCY AT LOWEST COST

Actual size #42 PowerGrip Flexible Coupling—2 hp. at 1750 rpm., 72 in./lbs. maximum torque. Also available up to 40 horsepower, at 1750 rpm. and torque loads up to 1440 in./lbs.

U. S. PowerGrip Flexible Coupling

- Compensates for greater angular and axial misalignment.
- Installed in minutes by eye. Horizontal or vertical application. No precise measurement required.
- Requires no lubrication, operates silently.
- Eliminates end thrust and shaft vibration.
- Machinery failure cannot harm equipment. Eliminates equipment damage due to overload or jam-up. The coupling disengages itself and can be instantly and inexpensively replaced.
- Costs less, requires no maintenance.

• • •

Your U. S. Power Transmission Distributor has a full stock of all sizes of U. S. PowerGrip Flexible Shaft Couplings. He is your best on-the-spot source for technical aid, quick delivery and quality industrial rubber products.

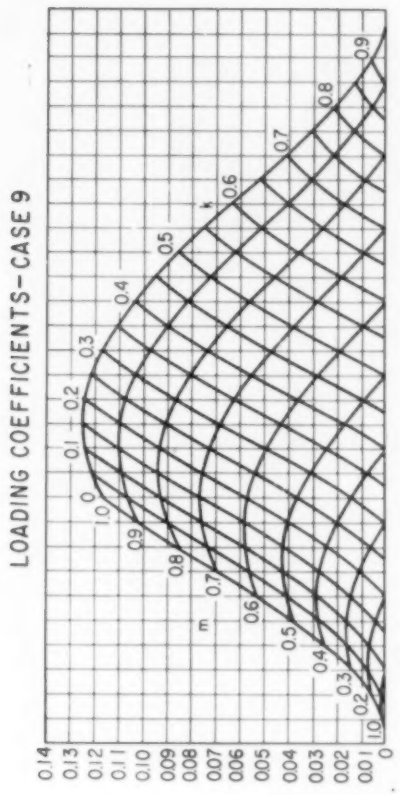
Mechanical Goods Division

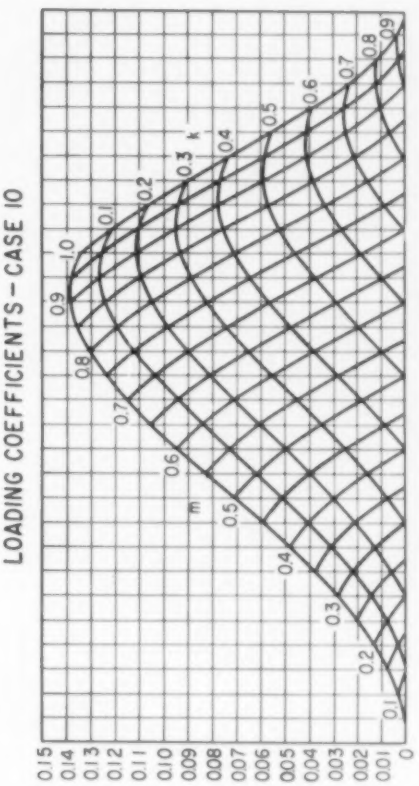
United States Rubber

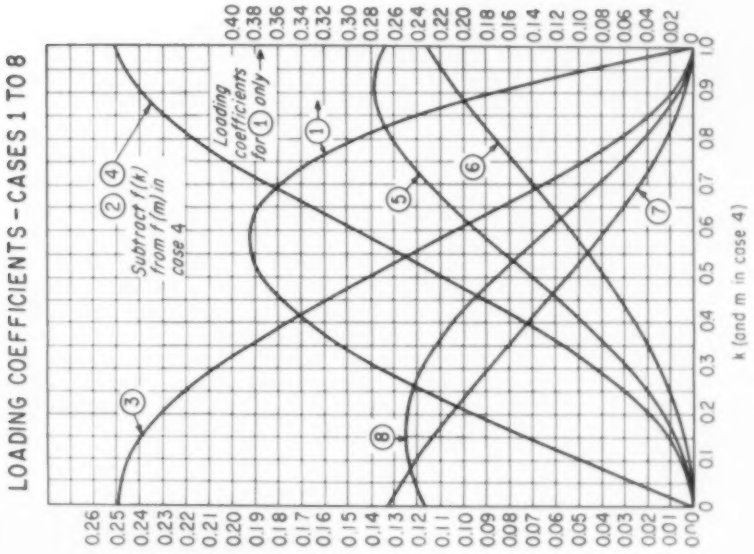
WORLD'S LARGEST MANUFACTURER OF INDUSTRIAL RUBBER PRODUCTS

Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

PARTIALLY LOADED CONTINUOUS BEAMS (cont.)







interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures . . . and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

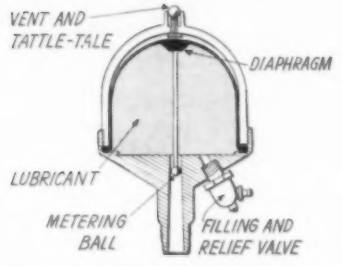
T-J TOMKINS-JOHNSON

SIGNIFICANT COMPONENTS MATERIALS PROCESSES

Automatic grease cup . . .

with visible control offers self-feeding lubrication for all plain or antifriction bearings. Clear plastic cylinder makes amount of grease in 4-oz-capacity reservoir visible at all times. As cup is filled with grease, plunger is pressed to top of cylinder, compressing spring. Spring and weighted plunger then feed grease to bearing with predetermined pressure. Protective valve prevents grease from entering bearings while cup is being filled. Internal ⅛-in. pipe threads in housing permit using any size pipe or extension to mount cup. $4.50 each. Immediate delivery. **Lubriquipment Engineers, PO Box 9194, Ft Worth 7, Tex.**

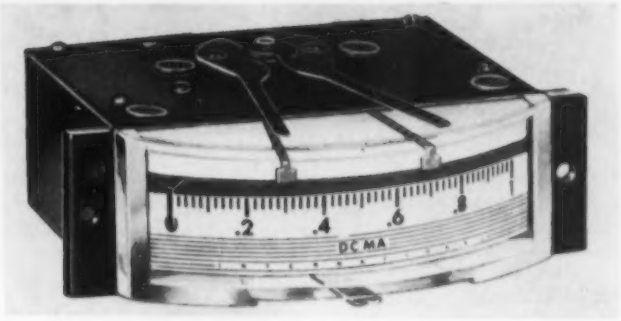
Circle 1, Reader Service Card



Compensated grease flow . . .

is achieved automatically in these grease cups by elastic diaphragm connected to metering ball. Diaphragm contraction as supply is depleted, changes position of metering ball in tapered cylinder and adjusts lubricant flow, compensating flow against varied diaphragm pressure. Diaphragm is filled to 10-oz capacity from inside. Bearing seals are protected by visual warning and relief valve. Lubricant is visible through transparent dome. Weighs 18 oz; measures 6½ x 3½ in. $18.50 each; 3- to 4-wk delivery. **Visiball Mfg Co, PO Box 7021, Ft Worth, Tex.**

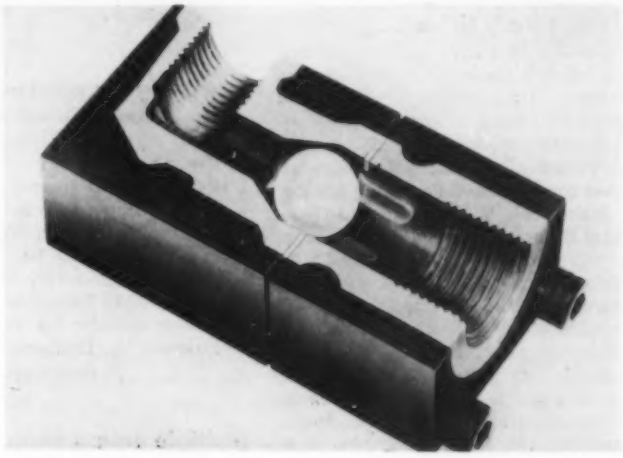
Circle 2, Reader Service Card



Miniature control meter . . .

operates without contacts at set points, permitting full scale of meter to be available for readings at all times. Additional current is not required to insure proper contacting, and such difficulties as contact resistance, flutter, corrosion and spotwelding are said to be eliminated. Control arms are adjustable over 80% of scale area from front of instrument. Meter and control circuits are separate and electrically isolated. Can be supplied for horizontal mounting. Scale length is 2.7 in.; panel area is 5.5 sq in. Accuracy is held to 2% of full scale deflection. Prototype samples in about 1 wk; delivery, about 6 wk. Tentative list price, about $120 each. **International Instruments Inc, PO Box 2954, New Haven, Conn.**

Circle 3, Reader Service Card

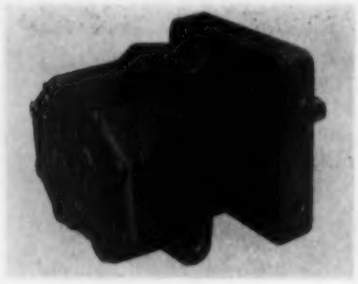


Fluorocarbon check valve . . .

is steel-armored and said to be impervious to most fluids, except molten sodium. Offered in burst pressure ratings to 1000 psi and above. Especially recommended for severely corrosive service. Available in ½, ¾ and 1-in. sizes, either threaded or ASA 150# flanged bodies. Either right-angle or in-line construction may be specified. Discounts to 25% max for 500 units or more of one unit apply. Threaded units are $22 for ½ in.; $23.10 for ¾-in.; $28 for 1-in. From stock. Flanged units are 40% higher. 2 to 3 wk delivery. **Keystone Engineering Co, 6315 England St, Houston 21.**

Circle 4, Reader Service Card

. . . . CONTINUED ON PAGE 78



Hydraulic gearpumps . . .

for operation at pressures to 2500 psi are offered in 14 sizes in 4 model groups with outputs of 1 to 60 gpm. All sizes are available for clockwise or counterclockwise rotation. Cartridge construction features minimum number of working parts. Pressure-balanced, self-compensating design eliminates major cause of internal leakage and is said to achieve improved performance over a wider range of operating speeds, pressures, temperatures and oil viscosities. *Volumetric efficiencies exceeding 90% are said to be normal. Housing is cast aluminum. Medium-size pumps in the line have a weight-to-hp ratio of under 1 lb per hp. Developed in England by Dowty Hydraulic Units Ltd. **Berry Hydraulics, Div Oliver Tyrone Corp, Oliver Bldg, Pittsburgh 22.**

Circle 5, Reader Service Card

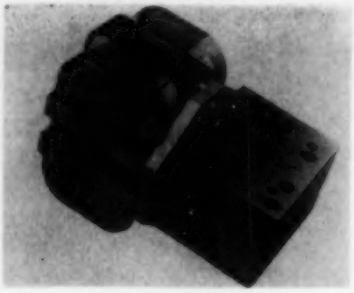
Direct rotary drive . . .

is provided by a servo actuator that does not use bell cranks or other mechanical linkages. Designed for hydraulic and pneumatic control or instrumentation systems where size, weight, positioning accuracy, speed of response and stability are prime considerations. Positioning accuracy is limited only by characteristics of associated servovalve and feedback transducer. Applicable directly or as a replacement for existing linear actuator and mechanical linkage systems. Depending upon load and compliance of supply fluid, response of 100 cps or greater is said to be possible. Available with power ratings from a fraction of a watt to 10 hp or greater. Breakaway pressure is less than 10 psi. **Parameters Inc, 195 Herricks Rd, New Hyde Park, NY.**

Circle 6, Reader Service Card

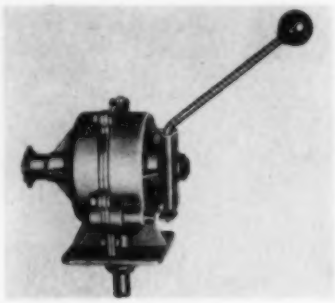
Flow-control servovalve . . .

for electrohydraulic servosystems where reliability and ruggedness are more important than extreme miniaturization and small electrical power requirements. Dc torque motor is capable of exerting over 13 lb of force. Motor idles during normal operation, but exerts full force when particle jamming or silting conditions are encountered, enabling valve to operate in



relatively contaminated fluids. Single-stage, four-way valve is rated to operate at supply pressures of 50 to 1000 psi. Max flow is 0.85 gpm and internal leakage is said to be 0.06 gpm max. Operates in temperatures of −65 to 265 F on input of 5.5 w max. Measures 2¼ x 2¼ x 3¼ in.; weighs 32 oz. **American Measurement & Control Inc, 240 Calvary St, Waltham 54, Mass.**

Circle 7, Reader Service Card



Reversing transmission . . .

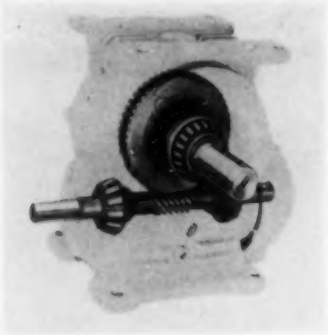
for vehicle manufacturers using engines to 5½ hp capacity. Right-angle drive with 2⅞:1 ratio weighs 7 lb, has 1 forward and 1 reverse speed and neutral. Unit is furnished with shifter lever and 8-tooth No. 41 hardened steel roller chain sprocket. Gears, shafting and shifter yoke are hardened for long service life. Unit is permanently lubricated. Mounts in any position. **J B Foote Foundry Co, PO Box 2214, Ft Dearborn Sta, Dearborn, Mich.**

Circle 8, Reader Service Card

Multiple rotary switch . . .

combines six 15-amp snap-action pushbutton switches, arranged around periphery of aluminum case and operated by common rotary shaft. Cam, coupled to shaft, operates individual switches in succession or more than one switch at a time. Switches are offered in SPST, normally open or closed; 2-circuit; 3-terminal, normally open or closed; or SPDT circuits. Each switch can be used as a separate pole, if desired. Similar rotary switch is available for 12-position operation. **Hetherington Inc, Folcroft, Penna.**

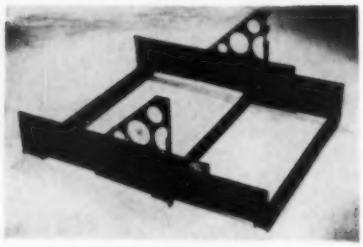
Circle 9, Reader Service Card



Worm gear speed-reducer . . .

mounts in three different positions. Available with worm shaft below gear, worm shaft on top of gear and with output shaft vertical in 2½, 3, 3½ and 4-in. centers. Rated up to 13.5-hp input and 7240 in.-lb output torque. Completely assembled units with ratios of 9⅜, 15½, 20½, 24½ and 50:1 are offered from nationwide stocks; ratios of 5⅛ to 60:1 are available from stock at factory. Auxiliary cooling not needed. One-piece housing is gray cast iron. Worm shaft is nickel steel forging. Worm gear is centrifugally cast phosphor bronze rim with cast iron center hub. **Link-Belt Co, Prudential Plaza, Chicago 1.**

Circle 10, Reader Service Card



Thin, lightweight slide . . .

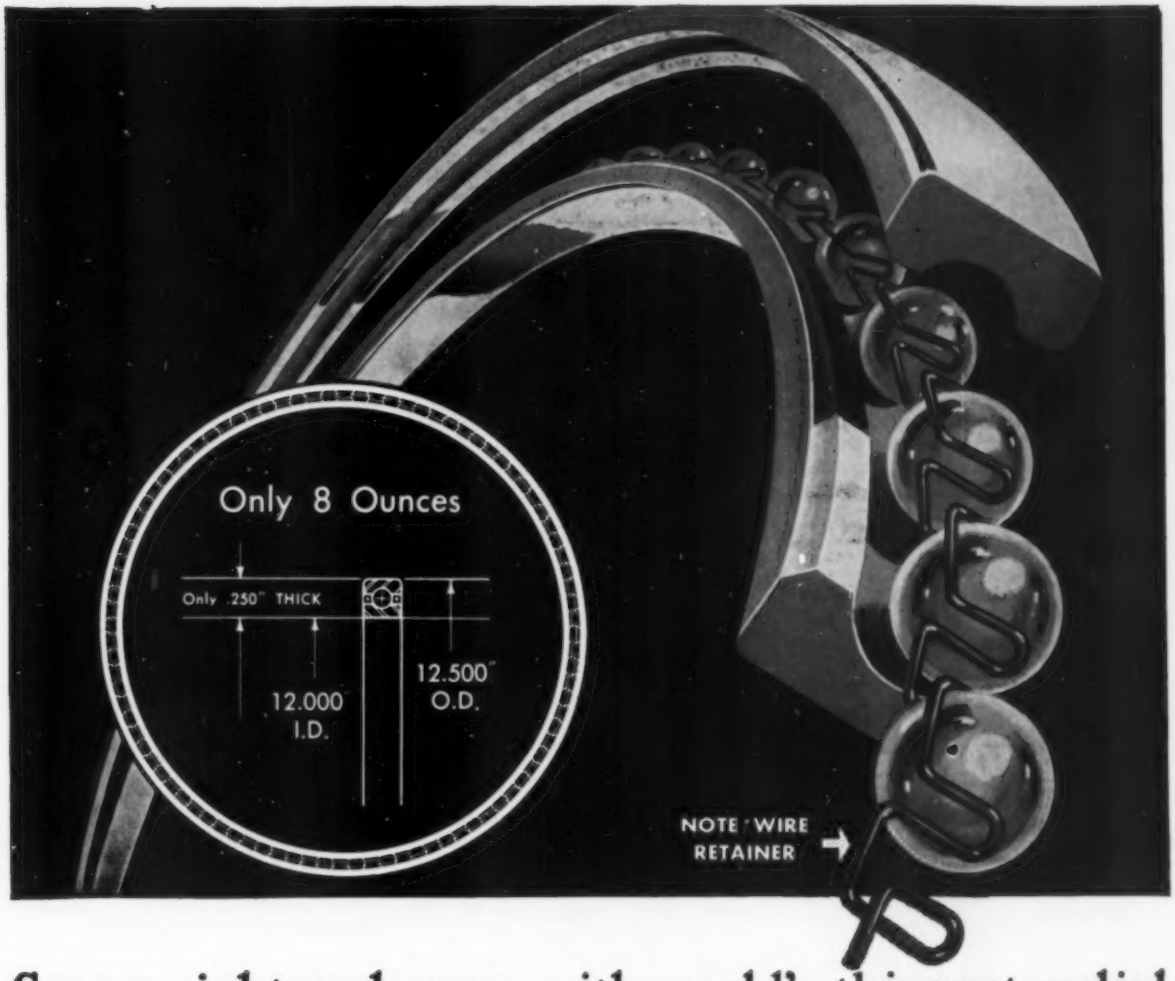
is 1.687 in. high and designed to carry a load of 50 lb max. Cadmium-plated before high pressure lubricant finish is applied. Offered in standard non-tilt model and basic model. Available, too, is a gusset mounting assembly for front reel rack and cabinet mounting. Gusset is factory preassembled and can be installed at work location. Gusset assembly is designed to fit all for standard slides. **Chassis-Trak Inc, 525 S Webster St, Indianapolis.**

Circle 11, Reader Service Card

Overheat motor protector . . .

safeguards against all abnormal conditions that can occur in a single-phase induction motor. In addition to protecting against five conditions covered by most presently used controls, unit is said also to safeguard

. . . CONTINUED ON PAGE 80



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

. . . now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

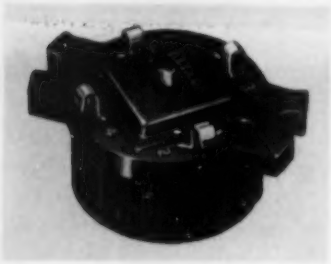
THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561R

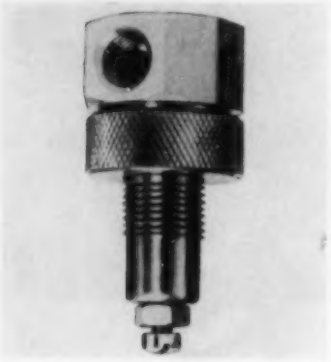
All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings



against locked rotor with starting winding only in circuit, such as that resulting from an open main winding circuit, or open circuit in reversing switch. For building into an electric motor to turn off power when windings get too hot. Motor protector ratings match various heating characteristics of motors. **Metals & Controls Corp, Attleboro, Mass.**

Circle 12, Reader Service Card



Air-pressure regulators . . .

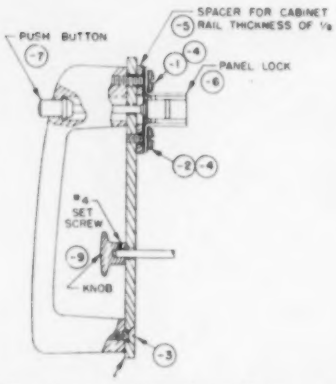
handle air flows to 20 cfm at 100-psi air pressure and provide regulation even with widely fluctuating line pressure and rapidly varying air flow. Can be used at max primary pressure of 400 psi and max delivery pressure of 100 psi. Operates in temperatures to 200 F max. Regulators have a brass bonnet and body, nylon-reinforced Buna-N diaphragm, Buna-N seat, hand-removable bonnet, in-line pipe connections. Can be serviced without removing from air line. Furnished with or without ⅛-in. NPT gage port; 1½ in. dia, 160 psi capacity back-mounted pressure gage. For left-to-right or right-to-left air flow. List prices start at $3.98. **C A Norgren Co, Englewood, Colo.**

Circle 13, Reader Service Card

2, 3-way solenoid valves . . .

for pressures of 3000 psi can be energized for extended periods without affecting operation. Poppet construction of 2-way valves is said to achieve leak-tight sealing when closed. Hardened and ground steel working parts are used in aluminum housing. Available in ¼, ⅜ and ¾-in. NPT sizes with capacities of 6, 8 and 30 gpm. for ac and dc voltage. The 3-way valves are operated by direct spool. Fitted steel spools in a steel housing are used. Available in ¾-in. NPT size for ac voltage and max working pressure of 200 psi. Valves mount in any position. Immediate shipment. **Fluid Power Accessories Inc, 2051 Railroad Ave, Glenview, Ill.**

Circle 14, Reader Service Card



Aluminum alloy handles . . .

are die-cast or sand-cast with a chip-resistant finish slurry baked on over a clear lacquer-base sealer. Finish is said to have passed 1000-hr salt spray test and 200-hr 100% humidity tests. Line of handles includes nine different designs with all-related hardware. **Chassis-Trak Inc, 525 S. Webster St, Indianapolis, Ind.**

Circle 15, Reader Service Card

Transistor-equipped power . . .

supplies offer modular design techniques to permit specification of only desirable features without paying for those not needed. Standard models, in addition to transistor-equipped regulation, incorporate a magnetic line-voltage regulator that causes voltage across transistors to drop to zero when output is shorted. Units have continuously variable output voltage with vernier control, ripple of less than 1 mv rms, recovery of less than 50 microsec with overshoot of less than 1% of voltage setting, external remote load change and cooling device. 25 different models range in price from $325 to $1595, FOB Springfield. **Mid-Eastern Electronics Inc, 32 Commerce St, Springfield, NJ.**

Circle 16, Reader Service Card

Switching transistors . . .

are said to have highest dc gain ratings of any now in production; also flattest beta curve. Provided in gain ranges of 50 to 100, 75 to 150 and 100 to 200 for optimum matching. Series has 5-amp max current rating and can switch power up to 400 w. Collector-emitter breakdown voltage ratings of 40, 70 and 80 eliminate burnout in high-voltage applications. Especially designed for use in power switching and power control circuits. Also suited to relay replacements and drivers for relays, magnetic clutches, solenoids and other loads requiring high current. **Bendix Red Bank Div, 201 Westwood Ave, Long Branch, NJ.**

Circle 17, Reader Service Card

Non-squeaking nylon hinge...

is for assemblies where minimum weight is mandatory, and produced in size, color, shape or finish to meet specifications. One-piece design needs no lubrication. **Heyden Newport Chemical Corp, 342 Madison Ave, New York 17.**

Circle 18, Reader Service Card

Microminiature indicator . . .

registers time that electronic and electromechanical devices have been in operation. Incorporates tiny electric motor and jeweled gear train with 180 million:1 ratio. Present models record up to 1000 hr. Single-phase, synchronous motor operates on 115 v ac, 400 cps and draws 0.018 amp at less than 1 w. Dimensions are 0.665 in. dia x 1.415 in. long. Weight is 1.2 oz. Said to withstand vibration of 10 g to 500 cps, temperatures of −40 to 165 F, and shock to 15 g. **Elgin Micronics Div, 366 Bluff City Blvd, Elgin, Ill.**

Circle 19, Reader Service Card

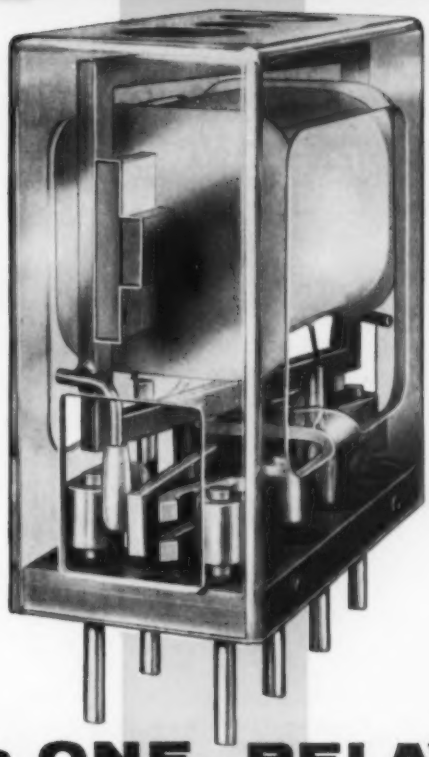
Miniature motor-pump . . .

for operating pressures 0 to 1000 psi at −65 to 225 F combines miniature hydraulic vane pump and 3-phase electric motor. Performance includes an output range of 0.6 to 1.5 gpm at 11,300 rpm and 1000 psi. Capacities can be increased by using mutliple vane pump cartridges stacked in an integral housing or by using double-ended motors. Dry weight of representative model in series

. . . CONTINUED ON PAGE 82

4 times actual size

Mock-up of CLARE Type F Relay enlarged to show operating mechanism. Note bifurcated contacts which enable this relay to handle a wide variety of contact loads.

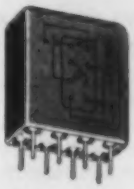


With this ONE RELAY

You can handle contact loads from 3 amperes down to 1 microampere, 1 millivolt

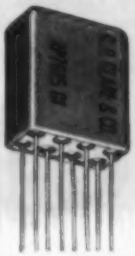
SPECIFICATIONS

Ambient Temperature	–65° C to +125° C.
Shock	65 Gs for 11 milliseconds.
Vibration	5-75 cps at maximum excursion of ¼ inch, 75-2000 cps at 20 Gs acceleration.
Dielectric Strength	Sea level—1000 volts rms between terminals and frame, and between adjacent circuits; 750 volts rms between contacts of a set. At 80,000 ft., 350 volts rms.
Insulation Resistance	1000 megohms minimum at 125° C.
Coils	Coils up to 10,000 ohms available for a wide range of voltage or current operation.
Nominal Operating Power	250 milliwatts.
Pickup Time	3.5 milliseconds nominal.
Dropout Time	1.5 milliseconds nominal.
Contact Arrangement	2 pdt (2 form C).
Contact Rating	3 amps resistive at 28 volts d-c or 115 volts a-c; also will handle loads of 1 microampere @ 1 millivolt reliably.
Contact Resistance	0.03 ohm maximum.
Contact Life	500,000 operations minimum at 2 amps; 100,000 operations minimum at 3 amps; 1,000,000 operations minimum at 1 amp.
Enclosure	Hermetically sealed, filled with dry nitrogen at 1 atmosphere pressure.
Mounting	All popular mounting arrangements available.
Terminals	Printed circuit; solder; plug-in (matching socket available). Variations of printed-circuit terminal length on 1/10-inch grid spacing available.
Weight	17 grams.
Military Specifications	MIL-R-25018, except as to contact bounce.



ACTUAL SIZE

All popular mounting arrangements are available. Terminal arrangements nicely suited to 1/10 inch grid spacing.



• In one relay—the Type F—CLARE provides a precise component of unusual flexibility for long life operation under a wide variety of contact loads.

Tests have shown a performance of over 22,500,000 operations at 0.1 ampere, 115 volts a-c. Minimum contact life at 3 amperes is 100,000 operations. Contacts have carried 1 microampere, 1 millivolt for 700,000 operations with a failure resistance of 500 ohms, with no misses recorded.

This amazing low-level life is primarily a result of the use of gold plated contacts. These same contacts, however, will carry up to 3 amperes.

A special plug-in mounting arrangement that will stand extreme shock and vibration is now available.

The CLARE Type F Relay is hermetically sealed, operates perfectly in a wide range of temperatures, withstands heavy shock and vibration—is fast and more than moderately sensitive.

Send for Engineering Bulletin No. 124

Write or call C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

FIRST in the industrial field

CIRCLE 137 READER SERVICE CARD

DRAFTING TRENDS

Color overlays using POST's new Vapo Chromtex color foils give this intricate drawing maximum readability with consistent color fidelity.

Color overlays tell faster visual story

Broader use of color overlays is more and more in evidence every day. Many engineers and designers have discovered that color provides a faster visual communication of highly complex subjects in technical manuals, intricate drawings, flip charts, "exploded" views and schematics.

Of course, color overlays are not new. But, until recently multiple sets had not reached their maximum performance potential. The Post laboratory has devoted more than two years in perfecting a series of ten color foils that meet the most rigid standards. Multicolor sets of films are now produced easily and quickly on any standard white print machine (dry diazo process). These new Post products are called Vapo Chromtex.

Post's technicians successfully eliminated difficulties previously encountered in some of the diazo films on the market, developing consistent color fidelity and the proper brilliance for most effective readability. Post's Vapo Chromtex films come in ten vivid colors: black, red, green, blue, orange, brown, magenta, cyan, yellow, and violet. These clean, bright colors offer a range that is broad enough to cover even the requirements of the most intricate graphic communication.

Unusually sharp image detail

Post Vapo Chromtex has a special acetate base which gives the necessary strength to resist buckling, and has desirable extra stability to insure accurate registration. Use of this base also provides a flat, uncurled print. Equally important, Post's Controlled Coating formulations assure unusually sharp image detail with clear, unclouded backgrounds.

Chromtex also offers good resistance to normal light, hence less image fade. This color foil series falls naturally into your normal reproduction routine. Each of the ten colors fully develop in one pass, and can be conveniently handled by any operator of ammonia process reproduction equipment.

Sample prints, processing data sheet available

If you want to know more about color overlays or if they have been a problem in the past, we will be glad to send you Post Vapo Chromtex sample prints and processing data sheet. *Write to Frederick Post Company, 3664 N. Avondale Avenue, Chicago 18, Illinois.*

POST

SENSITIZED PAPERS & CLOTHS • TRACING & DRAWING MEDIUMS • DRAWING INSTRUMENTS & SLIDE RULES
ENGINEERING EQUIPMENT & DRAFTING SUPPLIES • FIELD EQUIPMENT & DRAFTING FURNITURE

is 5.3 lb; occupies about 100 cu in. of space. Vane pump weighs 9 oz and delivers 0.6 hp at 1000 psi and 10,000 rpm. Can be manifolded with servovalves, miniature piston hydraulic motors and fhp electric motors. **Vickers Inc, Detroit 32.**

Circle 20, Reader Service Card

Sealed thermostat . . .

has all operating and lead connections contained within copper cup sealed with epoxy resin. Suitable for applications in −20 to 167 F range. Available for mounting on tubing or flat surfaces. Thermal element is snap-acting disk type. Switching action is either SPST or SPDT. Fixed temperature settings give spot temperature control, said to be unaffected by altitude or cross-ambient effect, at point of thermostat application. Electrical ratings for 6000 cps on terminals 1 and 3 are 16 amp, full load at 120 or 240 v ac; and 60 amp, locked rotor, at 120 or 240 v ac. Ratings for 6000 cps on terminals 1 and 2 are 15 amp, noninductive, 120 or 240 v ac and pilot duty at 125 v-amp, 120 or 240 v ac. **Metals & Controls Corp, Versailles Products Div, Versailles, Ky.**

Circle 21, Reader Service Card

Vertical-shaft engine . . .

is offered in two models: one with range of 2.5 to 6 hp, 1600 to 3600 rpm, and another with range of 3.5 to 7 hp, 1600 to 3600 rpm. Lubrication is supplied by vane-type oil pump that furnishes spray in crankcase to lubricate all internal engine parts. Ignition is supplied by dust- and weather-sealed, outside-mounted, high-tension magneto with im-

(Continued on page 84)

FAFNIR ANNOUNCES NEW, MODERN, COST-CUTTING DESIGNS IN SEALED BALL BEARING PILLOW BLOCKS!

LSA Standard Duty

LSAO Heavy Duty

Protection, economy, design-appeal featured in new LSA and LSAO standard and heavy duty units

Introduction of Fafnir LSA and LSAO pillow blocks opens new opportunities for improving both machine performance and styling, and reducing costs in standard and heavy duty applications.

Equipped with integral seal, wide inner ring ball bearings, the units are positively protected against contaminants and loss of lubricant. Fafnir-originated self-locking collars permit fast, easy, cost-cutting installation. Moreover, though the new series are made to the same base-to-center height dimensions and bolt-hole spacings as corresponding sizes in Fafnir's SA and SAO series, they are available at lower initial cost.

Housings are solidly built and of massive, streamlined design to harmonize with modern machine styling. All units are prelubricated and have provision for relubrication, if necessary . . . come ready to mount . . . and are designed to take radial, thrust, or combined loads in any position. Write for new bulletin showing sizes, dimensions, types, features. The Fafnir Bearing Company, New Britain, Connecticut.

FEATURES

Positive Protection — Slinger-type Mechani-Seals for protection at higher speeds; contact-type Plya-Seals for slow-to-moderate speeds, dirty or wet conditions.

Extra-Sturdy Support — Wide Inner Ring Ball Bearings with deep grooves and large balls for sturdy shaft support.

Simplest Installation — Fafnir-originated eccentric cam self-locking collar provides positive locking to shaft with twist of wrist. No machining, no mounting devices.

Self-Alignment — Spherical bearing O.D. and corresponding spherical housing seat assure self-alignment in any direction.

Modern Styling — Smoothly finished, streamlined, massive cast iron housing with machined bearing seat and base.

Plya-Seal

Integral Seal Ball Bearings

Mechani-Seal

Bearings in LSA units are Mechani-Seal type — or available optionally with Plya-Seals (RSA). LSAO series bearings are Mechani-Seal type, except those for shaft size 3¾", 3⅞", and 3 15/16", which have Plya-Seals (RSAO).

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

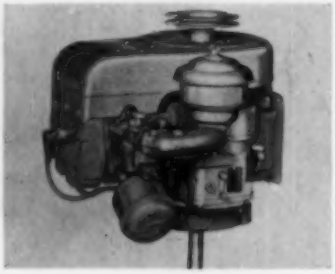
Don't get lost in a maze of wires!

Cut cost of assembly by as much as 65%, with printed circuits on TAYLOR copper-clad laminates

Conventional circuitry is a maze of wire and spaghetti. It is costly to assemble and unpredictable in performance. A printed circuit on TAYLOR rolled copper-clad laminate is a strong prefabricated part of known reliability. This quality is largely due to the new finish on the copper. Both solder and ink go on uniformly. The handling of one part alone can cut assembly costs as much as 65%. And there is an important passalong benefit: field repairs, when necessary, can be made easier and more economically. Write TAYLOR FIBRE CO., Norristown 39, Pa., for complete details.

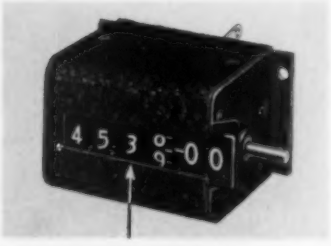
Taylor

LAMINATED PLASTICS VULCANIZED FIBRE



pulse coupling. Furnished as standard equipment. Built-in mechanical flyball governor, industrial type carburetor with semi-automatic choke release, oil-bath air cleaner are standard equipment. Cooling at all temperatures to 140 F is supplied by a large fan cast in flywheel, forcing air around cylinder and head. **Wisconsin Motor Corp, Milwaukee 46.**

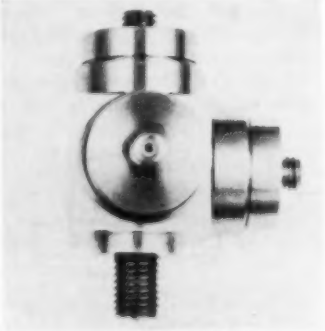
Circle 22, Reader Service Card



Direct-reading counter . . . makes possible immediate corrections of ambiguous readings, and can operate continuously at 6000 rpm. Directly geared second wheel is said to reduce wear that can occur from conventional transfer-pinion methods. White figures on black background are 0.250 in. high; case is about 2¾ x 2 x 1½ in. **Veeder-Root Inc, Hartford 2, Conn.**

Circle 23, Reader Service Card

Crystal accelerometers . . . that operate in ambient temperatures between —65 and 540 F without cooling or correction consist of 16 models, rang-



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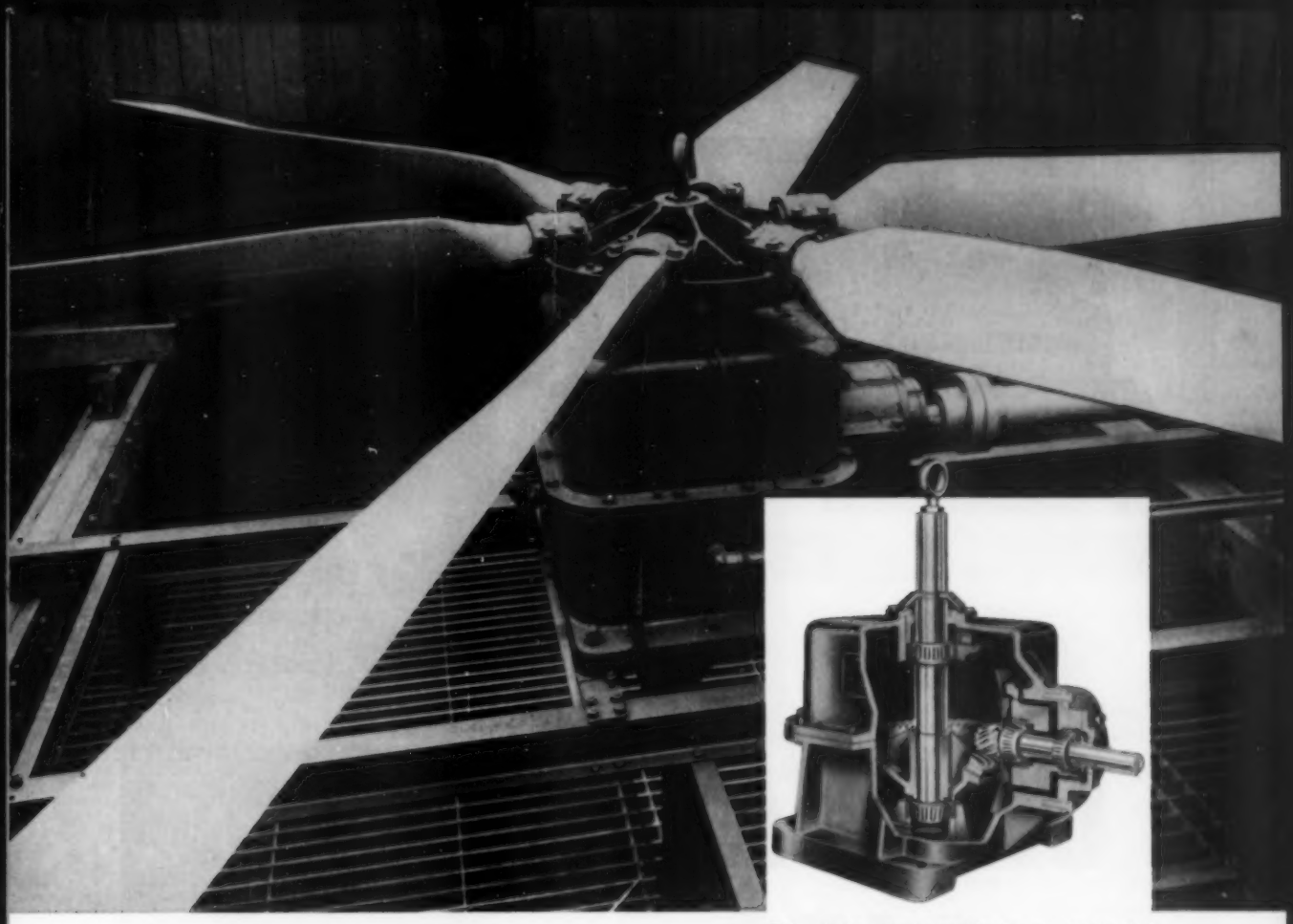


This spiral bevel gear combination permits the flexibility required to meet rugged 24-hour service while providing an economical, self-contained unit which requires practically no maintenance.

How to obtain help when you design bevel gear assemblies

The men who designed the gear reducer for the cooling tower fan shown above were assisted in many ways by Gleason engineers.

Cooling tower fan operation is generally recognized to be one of the most severe tests to which a gear reducer can be subjected. These towers demand a gear system that can operate twenty-four hours a day, three hundred and sixty-five days a year if necessary.

The gear reducer is subject to heavy loads and lies in the path of moist, corrosive air streams.

The gear drives for these cooling tower fans are subject to heavy loads and lie directly in path of moist, corrosive air streams.

Here is what the customer and Gleason engineers developed.

A spiral bevel drive of 19 x 76 combination and 2.5 DP. With spiral bevel gears the tooth bearing is localized which assures smooth and quiet operation and permits some mounting deflections without concentrating the load dangerously near either end of the tooth.

The use of this gear design also allowed the flexibility required to fit the fan unit into the over-all design of the tower and to produce an economical, self-contained unit which requires little or no maintenance.

Next, our engineers produced and tested prototypes of the design which the customer in turn tested in the final product.

Our engineers can also help you select proper mountings for such gear assemblies and advise you on such details as lubrication.

If you would like to take advantage of this service, write us the next time you have a problem involving bevel or hypoid gear systems. Furnish data covering type of application, loads and speeds and prints of the mountings. We would be pleased to assist you in the selection of your gears.

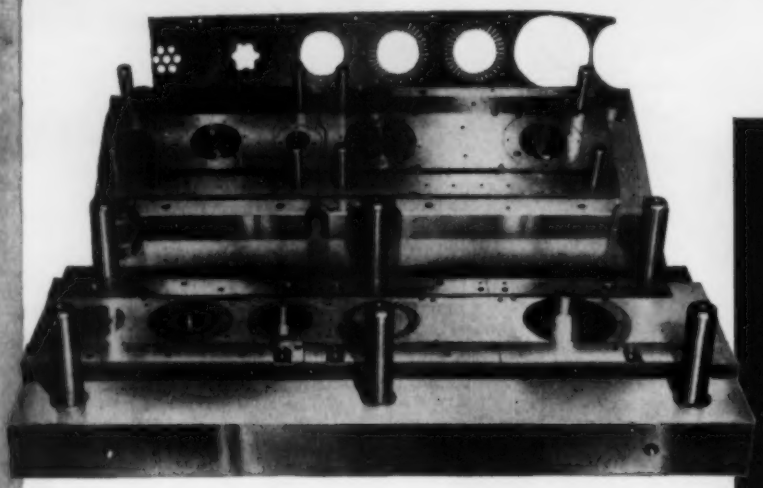
Meanwhile, you may find these Gleason Technical Handbooks helpful in your work:

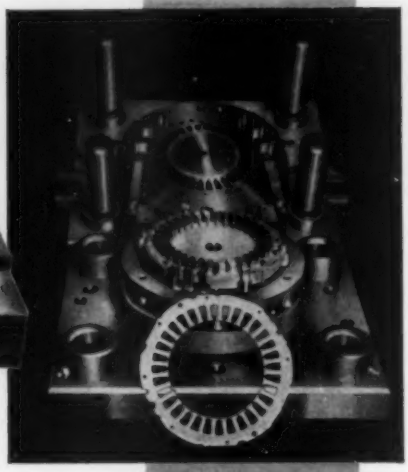
"20° Straight Bevel Gear System"
"Spiral Bevel Gear System"
"ZEROL Bevel Gear System"

GLEASON WORKS

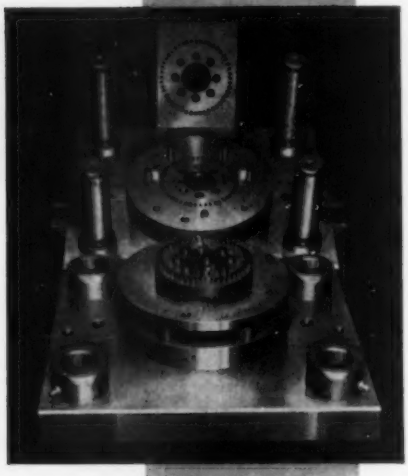
1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

64





CARBIDE DIES



designed and built by

Lamina
DIES AND TOOLS, INC.
P.O. BOX 31, ROYAL OAK, MICHIGAN

WE WOULD BE PLEASED TO QUOTE ON YOUR REQUIREMENTS

Now! With All-New High Efficiency Regulator!

ALEMITE

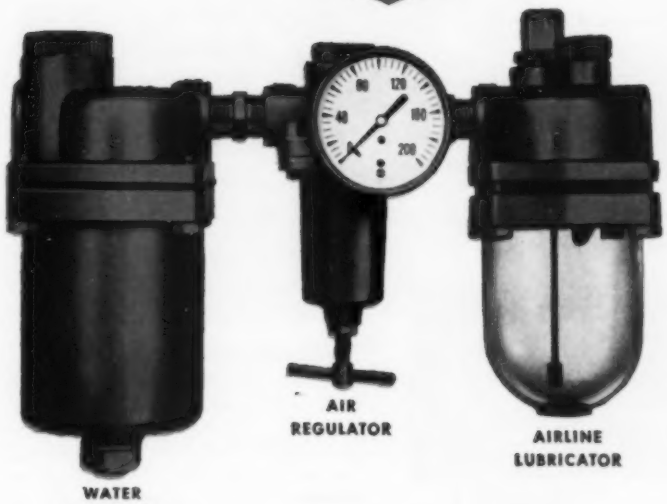
"Tri-Duty" Airline Controls

...FOR THE CLEANEST, DRIEST, BEST-REGULATED AIRLINE LUBRICATION...

Automatic Water Separator! Removes all of condensate, all the time. Traps dirt particles to prevent damage to sensitive airline devices. Handles all airline pressure up to 200 PSI and flow volume from 5 to 50 CFM.

New Air Regulator with Gauge! Assures accurately controlled air—prevents erratic operation and damage to equipment. Design permits inlet pressures of 250 PSI—adjustments up to 125 PSI. Excess air pressure "bleeds off," within regulator, instantly.

Automatic Airline Lubricator. Compensating ball valve design controls air flow. Oil particles are atomized for most efficient transmission through supply lines. Result—uniform mixture regardless of air pressure and volume. Oil and air mixture proportionately constant. Reservoir may be filled at any time, assuring continuous operation. Nine-ounce capacity.



ALL-NEW FEATURES OFFER OUTSTANDING ADVANTAGES:

- Ideal for air tools, air cylinders, air motors, etc.!
- Most efficient airline lubrication available!
- Specifically designed for extensive service life and peak efficiency under adverse operating conditions!
- Engineered to give greatest three-way protection, durability and efficiency . . . in a complete package!

Mail Coupon for Full Information!

Symbol of SW Excellence

ALEMITE DIVISION
STEWART-WARNER CORPORATION

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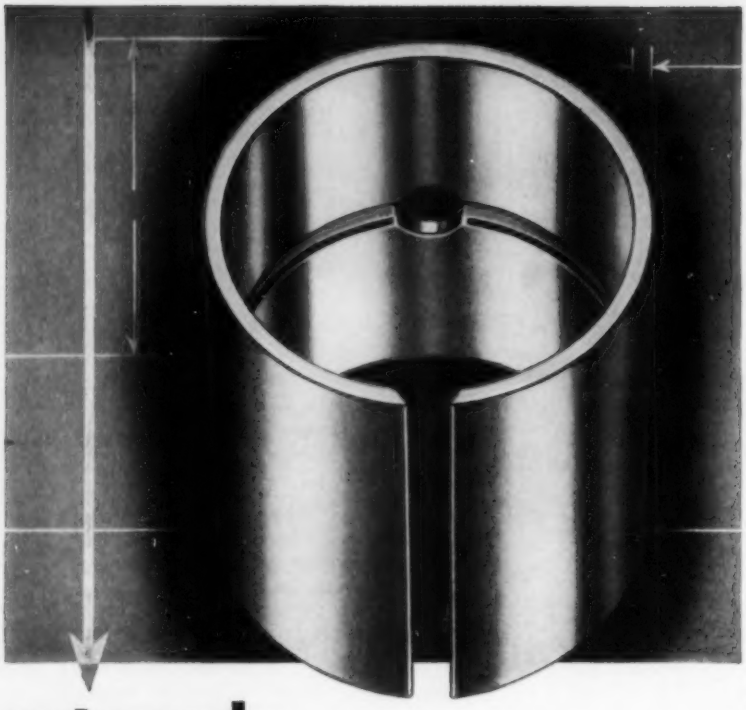
ALEMITE, Dept. AA-39
1850 Diversey Parkway, Chicago 14, Illinois
Please send me all the facts about Alemite's new "Tri-Duty" Airline Controls.

Name_____
Company_____
Address_____
City_____ Zone_____ State_____



extremely rigid specifications!

The illustration shows the cast bronze spindle bearing of a very well-known and popular metal-working lathe.

The manufacturer of this lathe has extremely rigid specifications covering tolerances, finish, structural quality of the bronze and roundness of the bearing even though the bearing is split for its entire length.

A manufacturer with such requirements naturally turns to Bunting to satisfy them.

For the unusual, as well as the usual, in bearings, bushings, bars or special parts of cast bronze or sintered metals, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

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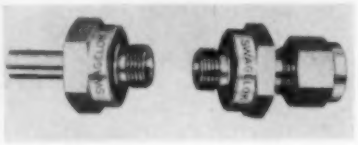
BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS.

ing from heavy-duty to subminiature types. Sensitivities range from 30 mv per g to 1 mv per g. Natural frequencies of 65 to 150 kc resulting from design and construction permit broad frequency coverage without spurious signals from resonance effects. Utilizes photoelectric crystal in true-compression seismic system to provide accuracy of 5% over acceleration and frequency ranges. **Columbia Research Laboratories, McDade Blvd and Bullens Lane, Woodlyn, Penna.**

Circle 24, Reader Service Card



O-ring fitting . . .

needs no sealant. Tapered pipe threads permit connection to existing female pipe thread. O-ring groove is integral with body of the fitting. Said to require no counterboring, no special tools. Available in all machinable metals and plastics in sizes for $\frac{1}{8}$ through 1-in.-OD tubing. Can be furnished in a variety of materials. **Crawford Fitting Co, 884 E 140th St, Cleveland 10.**

Circle 25, Reader Service Card

Transistorized tachometer . . .

is available in three basic models, for 19-in. rack panel mounting, as a portable unit, or with remote indicator. Models are self-powered by 9-v battery, but can be used with 115 v, 60 cps ac. Indicates speed of rotating shafts through use of magnetic or other speed pickup. Rpm is read directly on meter scale that can be calibrated in any speed range, with as many as 120 linear scale divisions. Speeds to 60,000 rpm are said to be measured accurately. Essentially a frequency meter, can be supplied for measurement of audio or ultrasonic frequencies. May also be adapted for use with any transducer that converts flows, pressures or other physical forces into electrical signals

(Continued on page 92)

UNIVERSAL ELECTRIC TYPE 118 FRACTIONAL HP MOTOR

*with new free-aligning Universal Bearing**

*PATENT APPLIED FOR

UNIVERSAL ELECTRIC announces a new, improved Type 118 four-pole, shaded pole motor featuring the NEW Free-aligning **Universal Bearing** that eliminates fractional hp motor bearing problems due to misalignment. With the axis of support in the center rather than at the end, and utilizing only the shaft itself for alignment, the new bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. The new bearing assembly provides longer bearing life, better lubrication . . . makes the Type 118 an easier starting motor that runs without a whisper of sound. More rugged and precision built from highest quality materials, the Type 118 is ideal for an unlimited number of applications that require maximum dependability with a minimum of maintenance, including kitchen ventilators, tape recorders, unit heaters, refrigeration equipment, window fans, record players, pump units, etc.

Write for complete information on the UNIVERSAL ELECTRIC Type 118 fractional H.P. motor and the new free-aligning **Universal Bearing.**

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

let your imagination run wild

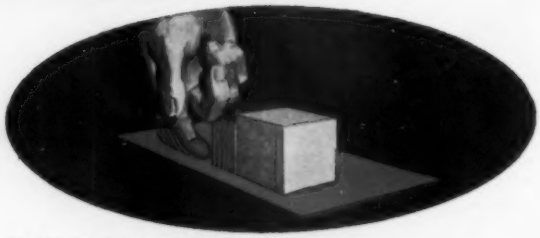
with this coating

EMRALON . . . Acheson's revolutionary new dispersion "opens the door" to a host of "restricted" applications

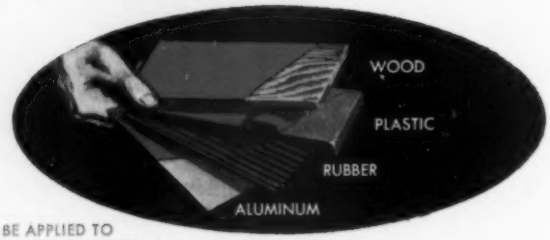
Five years in development, 'EMRALON' surface coatings now make possible the application of Du Pont Tetrafluoroethylene (TFE) to heat sensitive materials such as aluminum, rubber, wood and plastic. Applied by spray, these versatile resin-bonded lubricating films exhibit the low-friction properties of the TFE pigment together with the durability of their specially-selected binders. Thus, hundreds of potential uses which heretofore were impractical because of the high fusing temperature of other processes, can now be reconsidered as workable applications.

First in the Acheson family of TFE dispersions is 'EMRALON' 310,* employing a phenolic binder. Requiring a one-hour cure at only 300°F., it provides an unparalleled combination of low-friction coefficient, toughness, flexibility, adhesion and corrosion resistance. Substrates even more sensitive to temperature, or those where a bake cure is not practical, can be coated with 'EMRALON' 320† air-drying counterpart to 'EMRALON' 310.

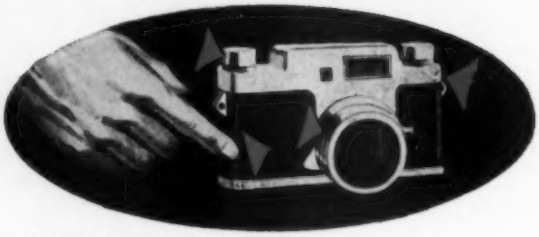
Evaluate 'EMRALON' 310 or 320 in your plant and be among the first to "open the door" to new design possibilities. Send for an introductory package complete with data sheet. Enough to coat 5,000 sq. in. of surface is yours for $4.25 prepaid ($4.50 west of the Rockies). Write today.



LOW COEFFICIENT OF FRICTION



MAY BE APPLIED TO HEAT-SENSITIVE MATERIAL



IDEAL FOR LIGHT LOAD MECHANISMS

Acheson Colloids Company
Port Huron, Michigan

Gentlemen: Your new 'EMRALON' surface coatings suggest themselves as possibilities for a current design problem. Send an introductory package to me promptly.

- ☐ 'EMRALON' 310 (bake type)
- ☐ 'EMRALON' 320 (air-dry)
- ☐ Bill me on Order No._____
- ☐ Check enclosed
- ☐ Please have your service engineer call:

NAME: _____ TITLE: _____

COMPANY: _____

ADDRESS: _____

CITY: _____ STATE: _____

APPLICATION: _____

*'EMRALON' 310 is manufactured under exclusive license from E. I. du Pont de Nemours & Co. (Inc.) under U. S. Patent 2,625,706. Not licensed for use or for sale for use in providing electrical insulation.
†'EMRALON' 320 — Patent applied for

ACHESON *Colloids Company*
PORT HURON, MICHIGAN
A division of Acheson Industries, Inc.
Also Acheson Industries (Europe) Ltd. and affiliates, London, England

CIRCLE 147 READER SERVICE CARD→

HERE'S WHY SO MANY ENGINEERS SPECIFY P&B's MH RELAY*

*AND VARIATIONS OF THIS BASIC STRUCTURE SHOWN BELOW

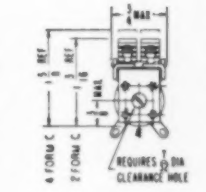
Shown with printed circuit terminals

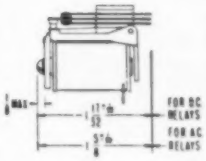
VERSATILITY

and adaptability are prime reasons why designers have made the MH a P&B best seller. This relay series, for example, does yeoman duty in such diverse applications as jet aircraft, street lighting equipment, computers and missile ground controls.

When multiple switching is required...when size, weight, long life and reliability are critical ...our MH relay can usually fill the bill. It's RIGHT for countless jobs, often at countable savings.

Let us send you complete information about this miniature telephone-type relay and the variations we've evolved for special applications. Write or call today.





ENGINEERING DATA/MH RELAY

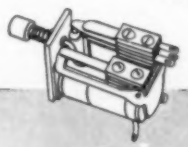
Insulation: Laminated phenolic.
Insulation Resistance: 100 megohms minimum.
Breakdown Voltage: 500 volts RMS between all elements.
Shock: Up to 30g.
Vibration: Up to 10g from 55 to 500 cps.; .065" max. excursions from 10 to 55 cps.
Ambient Temperature: −45°C. to +85°C. −(65°C. to +125°C. on special order).
Weight: 2½ oz. max. (open relay)
Pull-in: Approx. 75% of nominal voltage.
Pull-in Speed: Approx. 15 ms.
Drop-Out Speed: Approx. 10 ms.
Terminals: Pierced solder lugs; special lugs for printed circuits, taper tab (AMP #78).

CONTACTS:
Arrangements: Up to 9 springs per stack.
Material: ⅛" silver; also Palladium or gold alloy.
Load: Dry circuits to 5 amps @115V AC resistive.

COILS:
Resistance: 22,000 ohms max.
Power: 100 milliwatts per movable minimum to 4 watts at 25°C. max. (200 mw. min. to meet max. shock/vibration spec.)
Duty: DC: Continuous. AC: Intermittent (2 pole relay max.)
Voltages: DC: Up to 110 volts. AC: Up to 230 v. 60 cycles.
Current: 2.5 ma to 10 amps DC.

P&B STANDARD RELAYS AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

MC FOR RF SWITCHING
For RF switching where intercontact capacitance losses must be minimized. Ceramic contact spacers.



MA LATCHING
Electrical latch; mechanical reset. Small, versatile and offered with selection of contact arrangements.

MB CONTACTOR
Contacts rated 60 amp. 28 volts DC non-inductive. Will carry 150 amp. surge for a duration of 0.3 seconds.

MH SEAL-TEMP
Features sealed coil to minimize contact contamination. Available as hermetically sealed relay only.

POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

of variable frequencies. Accuracy is said to be 2% of full scale of meter reading. **Kahn and Co Inc, 547 Windsor St, Hartford 1, Conn.**

Circle 26, Reader Service Card

Adjustable drafting table . . .

is balanced in any position by counterweight mechanism operated by foot pedals. Multi-disk friction device locks and unlocks board to make height and slope simultaneously adjustable. Permits draftsman to work on any part of board, standing up or sitting down. Available in four board sizes: 40 x 60 in., 34 x 47 in., 26 x 36 in. and 27½ x 40 in. **Stacor Equipment Co, 285 Emmet St, Newark 5, NJ.**

Circle 27, Reader Service Card

Adjustable drafting table . . .

has a firm base with a foot-pedal-controlled height adjustment and board inclination. Action results from counterweight inside column of table. Table adjustment permits reference desks to be used on either side or in back of board. Draftsman can sit on any office chair and change drafting board positions from time to time, as desired and of most convenience to him. **Kuhlmann Straube Co Ltd, Box 358, Oakville, Ont, Canada.**

Circle 28, Reader Service Card

A NEW HIGH IN QUALITY CONTROL MEANS A NEW HIGH

in Quality Fasteners from

ALLEN

You'll sell better Cap Screws, and more of them, when you sell "*Allen Heads.*" Why? Long famous for advanced quality control techniques, Allen has expanded its Quality Control Division in its great new plant. From coil or bar stock right thru to the label on the box, each lot of Allenoy Steel is coded with its own number and checked with the finest equipment available. Furthermore, screws in process are gaged for dimensional accuracy right at the machines. The result is better performance – and that's what keeps customers happy!

LEADER POINTS — another Allen exclusive (No. 8 and up) . . . helps speed assemblies.

In Cap Screws, there's no substitute for Allen Quality. They're pressur-formd . . . for greater strength at vital points . . . with Class 3A threads, Class 2A above 1" dia.

Sell Allen **FLAT HEADS** for firm fastening with flush surfaces . . . Allen **BUTTON HEADS** for that streamlined look, without countersinking . . . Allen **STAINLESS STEEL CAP SCREWS** for corrosion and heat resistance plus high tensile strength. There you have 619 *standard* Allen items to better serve your customers. For details, write to Engineering Dept., Allen Manufacturing Company, Hartford 1, Conn.

ALLEN HEAD
HEX-SOCKET SCREWS

THE PEOPLE WHO KNOW REFRIGERATION BEST

DEPEND ON THE PEOPLE WHO KNOW TUBING BEST!

He Goes To Any Lengths To Help Solve Your Tubing Problems!

This guy really gets around. He's Connie Habecker, GM Steel Tubing Sales Product Engineer. Today he's flying West with another solution to a customer's tubing problem: How to produce a new serpentine design on existing high-production equipment that will mean real savings. Tomorrow, he's scheduled for a meeting with design engineers on the East coast to go over blueprints of a new condenser design. His customers have learned that Connie can help them save money by calling on him early in the game. His engineering background includes valuable knowledge of design and production. And he really knows his tubing, and what it can do . . . for you and your product. He knows GM Steel Tubing is steel-strong, capable of taking any shape. And he knows it's quality-controlled many times beyond specifications . . . cleaner, in fact, than any other tubing you can buy. Put some on test today and see why GM Steel Tubing leads in refrigeration sales . . . by miles!

SEE SWEET'S CATALOG 1o/Ro

Rochester Products Division of General Motors, Rochester, New York

GM STEEL TUBING BY ROCHESTER PRODUCTS

AMERICA'S LARGEST MANUFACTURER OF REFRIGERATION TUBING

←CIRCLE 148 READER SERVICE CARD

CIRCLE 149 READER SERVICE CARD

MEL-TROL® gives you **design insurance**

on forged high temperature parts

This turbine wheel forging will be machined down to 1/16 in. thickness in some sections.

The better the forgeability, the easier and less costly the machining. But there can be no sacrifice of high temperature properties when you are depending on the strength of a minimum cross section, as this design does.

The only way to get both forgeability and uniform high temperature performance is to make sure of the uniformity and quality of the steel itself. To get a uniform forging, you have to start with a uniform billet. And a uniform billet can only come from a uniform ingot.

That's what MEL-TROL gives you.

Users of MEL-TROL high temperature alloys report they are the cleanest forging alloys of their type. Their performance in service is consistently good. It minimizes the variations in service life found in conventional alloys.

It's the result of the finest quality control tools and procedures known today used together with a new, *Carpenter*-patented mold which produces ingots with the highest uniformity yet achieved in commercial steelmaking.

And it's easy to get this new kind of "design insurance." Just call the nearest *Carpenter* Service-Center. The Carpenter Steel Company, 117 W. Bern Street, Reading, Pa.

Carpenter STEEL

The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

1. Bronze Bearing, with self-adjusting "U" Cup Piston Rod Seal for longer wear.
2. Rod Wiper protects Piston Rod Seal and keeps Cylinder clean.
3. "U" Cup Seals expand with pressure to provide positive seal with minimum friction.
4. Wrench Flats make for easy installation.
5. Ground, hard chrome-plated Piston Rods have minimum yield strength of 125,000 psi.
6. Self-locking cushion adjusting screw and ball check are below surface for protection . . . easily accessible.
7. For extra strength, Cylinder Ends and Mounting Plates are machined from bar stock and steel forgings.
8. Cylinder is precision-finished brass for extra heavy duty.
9. Variety of mountings can be interchanged—easily match any installation requirement.
10. Interchangeable with all JIC Cylinders.

SCHRADER SQUARE-END CYLINDERS

meet and exceed JIC specs . . . 250 psi air . . . 750 psi hydraulic!

Here's compact, versatile straight-line power. Just look at the features!

Use Schrader's new square-end double-acting cylinders for holding, positioning, moving work—for push, pull or lifting—for automating manual operations. In five sizes up to 4-inch bore, and with five interchangeable mountings, these "square-ends" are economical and versatile. Bolt, leg, flush, side flush or base . . . each JIC Cylinder will mount all five ways. Suitable for air pressures to 250 psi, or hydraulically to 750 psi—available cushioned or non-cushioned.

You get safe, controlled, low-cost power with Schrader "square-ends"—another addition to the line of famous Schrader quality Air Control Products.

Complete stocks available locally—expert help to improve your air control hookups. Write for your complete specifications and data on these new "square-ends."

Bolt Mounting **Leg Mounting** **Flush Mounting** **Side-Flush Mounting** **Base Mounting**

Schrader
a division of SCOVILL

A. SCHRADER'S SON
Division of Scovill Manufacturing Co.
457 Vanderbilt Avenue, Brooklyn 38, N. Y.

QUALITY AIR CONTROL PRODUCTS

in Kel-F, Viton-A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to +500° F.

LINEAR—specialists in close-tolerance molding in all of today's modern polymers . . . in both fabric reinforced and homogeneous materials.

These are automatic seals. For further help, call the LINEAR engineer.

PERFECTION IN RUBBER
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LINEAR Inc. STATE ROAD & LEVICK ST. PHILA 35, PA

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 101.

HYDRAULIC CYLINDERS—Catalog, 84 pp. Engineering reference data includes dimensional drawings of basic designs that, with modifications, achieve economic cylinders to fit specific product application requirements. Benton Harbor Engineering Works Inc, 622 Langley Ave, St Joseph, Mich.

Circle 29, Reader Service Card

ABRASION-RESISTANT ALLOYS—Booklet, 36 pp. Discusses different types of abrasion, followed by a consideration of the performance of molybdenum-containing alloys under conditions typical of certain types of abrasion. Practical guidelines are given for production and treatment of alloys. Climax Molybdenum Co, 500 5th Ave, New York 36.

Circle 30, Reader Service Card

FRICTION AND FLUID DRIVES—Bulletin 314, 20 pp. Condensed specifications on all friction and fluid drives. Engineering data, schematics, dimensional information and characteristics for a particular unit are contained on one page for ease of reference. Twin Disc Clutch Co, Racine, Wis.

Circle 31, Reader Service Card

V-BELT DRIVE—Bulletin A-695, 44 pp. Explains construction of line of V-belts and sheaves that permits delivery of increased hp in a given space. Tables give hp capacities, belt speeds, center distances and other engineering information. Dodge Mfg Corp, Mishawaka, Ind.

Circle 32, Reader Service Card

DUCTILE IRON PRODUCTS—Catalog, 36 pp. Gives grades, specifications, dimensions and weights, uses and applications. Also describes and illustrates fabricating facilities and testing and inspection facilities. American Cast Iron Pipe Co, PO Box 2603, Birmingham 2, Ala.

Circle 33, Reader Service Card

LITERATURE INDEX—Bulletin G2-1a, 24 pp. Lists product, technological and application literature published by company. Educational aids and company services are also described. Minneapolis-Honeywell Regulator Co, Wayne & Windrim Ave, Philadelphia 44.

Circle 34, Reader Service Card

O-RINGS—Bulletin AD-148, 20 pp. Discusses design, materials of construction, dynamic and static applications, use of backup or non-extrusion rings and groove design for packing. Garlock Packing Co, 432 Main St, Palmyra, NY.

Circle 35, Reader Service Card

PLASTIC PIPING SYSTEMS—Handbook C-159, 16 pp. Describes plastics used, installation and coupling methods, standards; has temperature and working pressure chart for valves and table showing effects of 280 chemicals on five different plastics. Chemtrol, 10872 Stanford Ave, Lynwood, Calif.

Circle 36, Reader Service Card

ROTATING SERVO NOMENCLATURE—Booklet 560, 12 pp. Covers standard Mil-type synchros, resolvers, servomotors and tachometer generators. Includes explanation of identification symbols and definitions of unit characteristics. Ketay Dept, Norden Div, United Aircraft Corp, Commack, NY.

Circle 37, Reader Service Card

AC MOTOR SELECTION—Bulletin B-2103-4, 12 pp. Explains NEMA design classes, speed-frequency relationship, current and torque values and gives frame selection tables and dimensional information. Reliance Electric and Engineering Co, 24701 Euclid Ave, Cleveland 17.

Circle 38, Reader Service Card

MOTOR APPLICATION GUIDE—Booklet 270-A, 16 pp. Describes nine major factors in motor selection, followed by selection charts for polyphase, single phase and dc motors. Also, information on Century's gearmotor line, selective speed drives, mechanical variations and special applications. Century Electric Co, 18th and Pine Sts, St Louis 3.

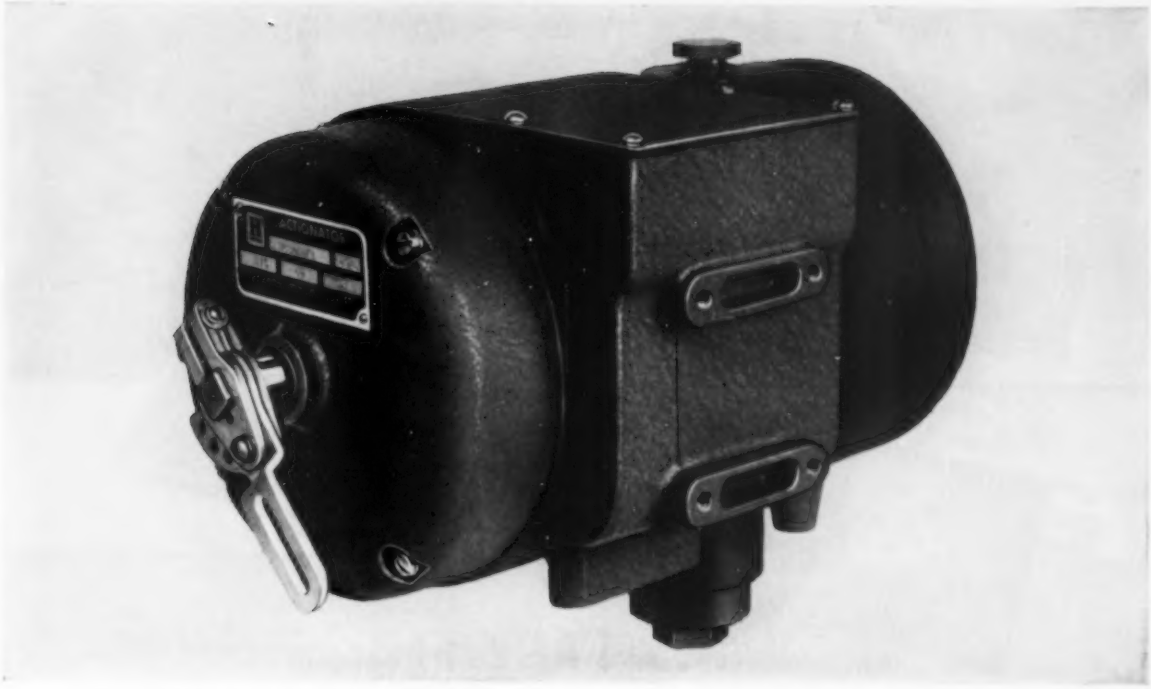
Circle 39, Reader Service Card

INDUSTRIAL AND AUTOMOTIVE ENGINES—Brochure, 12 pp. Gives power ratings and over-all dimensions on over 100 in-line, V and turbopower engine models. Detroit Diesel Engine Div, General Motors Corp, 13400 W Outer Dr, Detroit 28.

Circle 40, Reader Service Card

RESISTANCE OF ELASTOMERS TO HIGH AROMATIC FUELS—Report, 12 pp. Study is based on recent laboratory study comparing effects of high aromatic

(Continued on page 100)



NEW ACTIONATOR* heavy-duty electric motors operate slip stem valves

Use the powerful new ACTIONATOR industrial type motors to operate vertical acting stem valves having lifts of ½ inch through 1½ inches. Double-ended shaft can also simultaneously operate butterfly valves, rotary stem valves and other devices through suitable linkages.

ACTIONATOR motors are available with a variety of speeds, from 7.4 to 120 seconds full-stroke operation. The high speed permits use with pulse-type controllers such as those used in radiant tube firing. Torque ratings range to 200 inch/lbs.

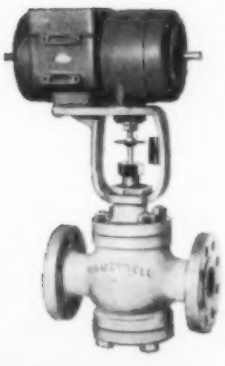
*Trademark

Other features include built-in linkage and strain relief, mounting yoke, and enclosed terminals with gasketed housing to meet JIC specifications.

Models are available with two-position, floating and proportional control. Optional models can include either one or two cam-operated, internally mounted switches for a variety of dual switching purposes. The compact assembly is self-supporting and requires no auxiliary mounting bracket. Other ACTIONATOR motors are available for use with rotary shaft type valves, dampers, louvers, or other final control elements.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.



Choose valve bodies to work with ACTIONATOR motors from Honeywell's complete line of single-seated, double-seated and three-way types.

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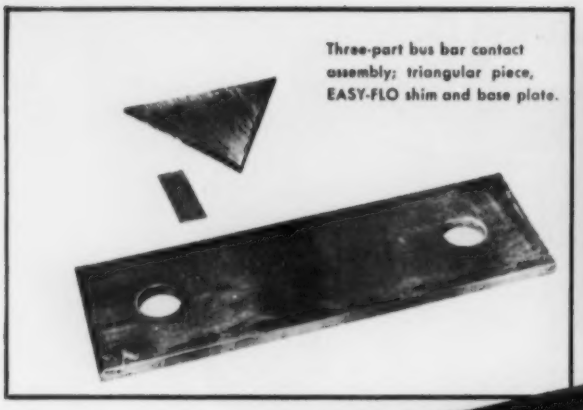


Three-part bus bar contact assembly; triangular piece, EASY-FLO shim and base plate.

Assembly under heat.

Note smooth, even fillet of completed assembly.

EASY-FLO "Moves in All Directions" to Braze Bus Bar Contact

Specialty Brazing Laboratory, Riverside, Connecticut, brazes, among other things, a bus bar contact for Rolock, Inc., Fairfield, Connecticut, makers of fabricated metal products. While a relatively simple assembly, it points up the remarkable *fluidity* of Handy & Harman Silver Brazing Alloys.

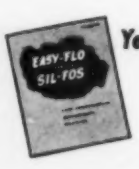
Both assembly components are copper. Base plate dimensions are ¼" x 8¾" x 2¾", and the ⅛" thick triangular piece is 3" on its base with 2⅛" sides.

After cleaning, the joint area of the base plate is HANDY-FLUXED and a shim of EASY-FLO 45 is placed on the base plate and the triangular piece set upon the shim. Heating by Selas gas-air burners is done on a 50-second cycle. Alloy cost is approximately four cents per assembly.

You'll notice, in the photo of the completed assembly, how smooth the alloy fillet is. The capillary action of EASY-FLO causes it to flow out in three directions, providing even joint penetration. This single fact (without going into the qualities of strength, conductivity, corrosion resistance, etc.) makes EASY-FLO a natural for electrical applications. Handy & Harman has, readily at hand, extensive data on the advantages of silver brazed joints for electrical applications. We are always ready and happy to discuss joining requirements and techniques with you. Your call or inquiry will bring complete and beneficial details.

FIRST, BULLETIN 20

This informative booklet will get you off to a good start on the values, techniques and economies of low-temperature silver brazing. A copy awaits your request.



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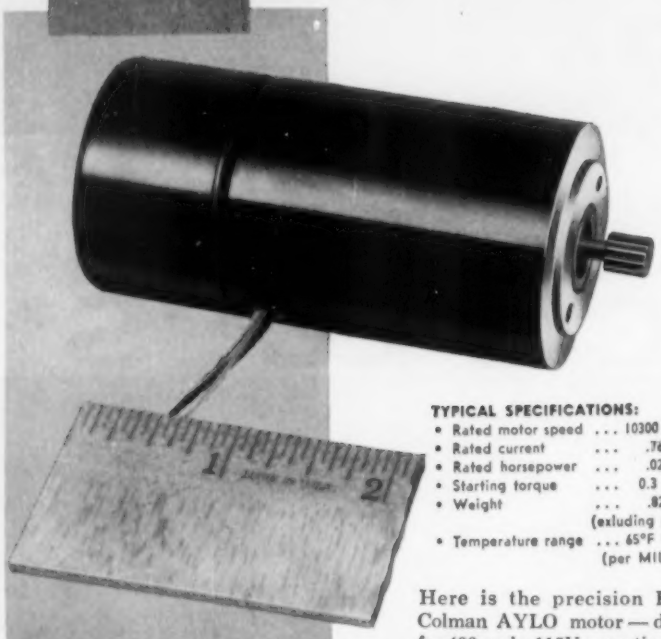
THE MARK OF QUALITY

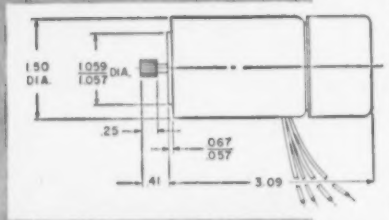
BARBER COLMAN

400-cycle motors for aircraft/missile applications



TYPICAL SPECIFICATIONS:

- Rated motor speed ... 10300 rpm
- Rated current ... .76 amp
- Rated horsepower ... .020
- Starting torque ... 0.3 lb-in.
- Weight ... .82 lb (exluding capacitor)
- Temperature range ... 65°F to + 250°F (per MIL-M-7969b)



Here is the precision Barber-Colman AYLO motor — designed for 400 cycle, 115V operation. Four-pole field . . . two balanced windings permit reversal with an SPDT switch... unit shown has 400-cycle brake which has a minimum life of 300,000 cycles. This motor has passed MIL-M-7969a qualification tests . . . motor life 1000 hours when tested per these specifications. Write for technical bulletin.

THE WIDE LINE OF BARBER-COLMAN ELECTRICAL COMPONENTS includes: *D-C Motors* for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . permanent magnet and split series types . . . various mountings and speeds . . . also available with gearheads or blowers. *Tach Generators* for accurate speed indication and servo rate control applications. *Choppers* that require extremely low driving power. *Resonant Relays* characterized by low operating power, narrow band width. *Ultra-Sensitive Polarized Relays* operating on input powers as low as 40 microwatts. *400 Cycle A-C Motors* for aircraft and missile applications.

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fuels on oil-resistant elastomers. Tables of data and curves are included. Thiokol Chemical Corp, 780 N Clinton Ave, Trenton 7, NJ.

Circle 41, Reader Service Card

WOVEN GLASS-BASE INSULATING TAPES, FABRICS—5 bulletins, 2 pp each. Properties and applications of glass tapes, fabric sheets, wrappers and die-cut pieces, both silicone-varnished and rubber-coated. Continental-Diamond Fibre Corp, Newark 107, Del.

Circle 42, Reader Service Card

SELENIUM RECTIFIERS—Catalog, 10 pp. Presents descriptions and specifications, gives 4 pp of continuous dc ratings for 26, 33, 36, 40, 45 and 52-v rms cells, and illustrates rectifier circuits. Syntron Co, 240 Lexington Ave, Homer City, Penna.

Circle 43, Reader Service Card

MANOMETERS—THEORY AND APPLICATION—Brochure, 8 pp. Principles and terminology encountered in manometry are explained; different types of manometers are described, and a number of applications with working diagrams are presented. Dynametrics Corp, Northwest Industrial Park, Burlington, Mass.

Circle 44, Reader Service Card

MANOMETERS—Catalog T-1771, 12 pp. Specifications, ratings and illustrated descriptions of two new models and other manometers made by firm. Trimount Instrument Co, 3119 W Lake St, Chicago.

Circle 45, Reader Service Card

SELENIUM PHOTOVOLTAIC CELLS—Bulletin PC-649A, 8 pp. Describes over 25 standard selenium cell types, including cell structure and operation, performance characteristics, output-current curves and typical applications. International Rectifier Corp, El Segundo, Calif.

Circle 46, Reader Service Card

ROOM-TEMPERATURE VULCANIZING SILICONE RUBBER—Bulletin CDS 170, 8 pp. Includes product and application information on three new compounds, available in several viscosities. Gives property data in tabular form. General Electric Co, Waterford, NY.

Circle 47, Reader Service Card

MINIATURE BEARING LUBRICATION—Manual 5810, 26 pp. Supplies information on various oils and greases available to bearing designers and users. Manual covers oil and grease lubrication, properties, military specs, standards and special lubricants. Miniature Precision Bearings Inc, Precision Park, Keene, NH.

Circle 48, Reader Service Card

INSTRUMENT AND CONTROL SWITCHES—Bulletin 14B8112B, 8 pp.

(Continued on page 101)

Covers construction, advantages, applications, operation and components of Type 210 switches. With dimensional drawings, diagrams and photos. Allis-Chalmers Mfg Co, Milwaukee 1.

Circo 49, Reader Service Card

Letterhead Requests Only

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

MOLDED RUBBER—Handbook, 45 pp. Describes properties, uses and processing methods involved in working with rubber. Gives characteristics of rubber formulations, properties obtainable from various molding methods and design factors. Stowe-Woodward Inc, Newton Upper Falls 64, Mass.

TUBING AND SLEEVING—Selector card, 8¼ x 11 in. Contains samples of 21 grades of insulating tubing. Pertinent information on each type of tubing and sleeving is presented in chart form. Physical, electrical, chemical, thermal, and other specs are given under sample to which they pertain. Suflex Corp, Dept 130, 33-40 57th St, Woodside 77, NY.

INDUSTRIAL NOZZLES—Catalog 59, 32 pp. Listings and data for all types of nozzles for industrial spraying applications. Covers spray angles, dimensions, types of connections and capacity vs pressure for all standard nozzles. Applications section is included. Wm Steinen Mfg Co, Industrial Nozzle Div, 45 Bruen St, Newark 5, NJ.

COBALT—Data sheet, 5 pp. General information, data on electrical and magnetic, mechanical and high-temperature properties, transformations, diffusion, solubilities of oxygen in cobalt and hot hardness. Also included is data on 99.6% pure cobalt. Cobalt Information Center, c/o Battelle Memorial Institute, 505 King Ave, Columbus 1; or, outside the Americas, Centre d'Information du Cobalt, 35, Rue des Colonies, Brussels, Belgium.

SILICON AND SELENIUM RECTIFIERS—Short-form catalog, 16 pp. Gives ratings, electrical characteristics and descriptive data on 405 types of silicon and selenium rectifiers and diodes. International Rectifier Corp, 1521 E Grand Ave, El Segundo, Calif.

MOTOR SELECTOR — Chart, index tabbed. Motor control ratings, sizes, features, catalog numbers and ordering instructions are presented. Final 2 pp contain listing of standard heater tables. Arrow-Hart & Hegeman Electric Co, Industrial Control Div, 103 Hawthorn St, Hartford 6, Conn.

BARBER COLMAN

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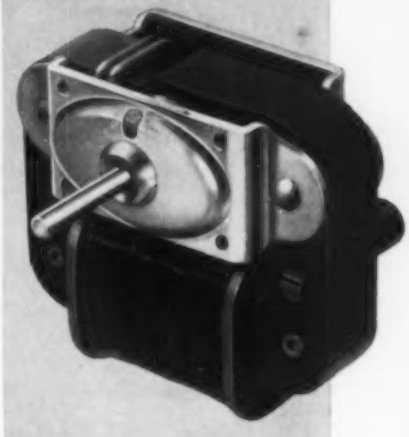

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Get the helpful condensed catalog of Barber-Colman shaded pole small motors. Contains complete descriptions of above motors, shows typical specifications, performance characteristics, control circuit diagrams. Write for your copy.

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Need a Fastener that Hasn't Been Invented?

Chances are you'll pay top price for it. But by following these six rules you can avoid the high cost of becoming an inventor!*

IT'S natural to assume that, after designing a piece of equipment, you'll have no trouble finding standard fasteners to fit it. Usually such fasteners will be readily available. But what happens when you find yourself with a finished design that doesn't lend itself to any known fastening method?

The most expensive thing you can do at this point is to start inventing fasteners. Valuable man hours go into research, design, prototypes and testing. And unless you can make these fasteners in very large quantities the unit cost will be high, particularly if tooling is necessary.

Now, here are six tips that can get you out of trouble—and keep you out:

1. Remember—not all standard specialty fasteners are listed in fastener manufacturers' catalogs. The fastener company that serves you is probably tooled up for hundreds of non-standard devices, designed and produced to solve problems like yours for other customers. Maybe one would meet your requirements. You'd save the development and tooling charges.

2. There may be a stock fastener available for this job that hasn't come to your attention. Discuss the problem with the fastener manufacturer. If he has nothing in stock, he may be able to modify one of his standard devices at very nominal extra cost.

3. Don't overlook free professional help! Your fastener manufacturer will be glad to offer advice and design service—he does it for everyone else. Unload the problem on him, and let his experience work for you.

But you'll save money if you avoid specifying the fastener that hasn't been invented. By following the next three rules you can usually keep from reaching the point where a non-standard device might be necessary.

4. Go into the fastening problem during the early stages of design. Design your closures with standard fastenings in mind. You won't be left with the costly choice of inventing a fastener or redesigning your product.

5. Keep a complete file of fastener manufacturers' catalogs. Your product designers seldom are fastener specialists too, but they can have complete information available when they need it—at the design level.

6. Work closely with the Fastener Sales Engineer who calls on you. He's trained and paid to help solve your problems. Take full advantage of this service.

Whether you need a standard specialty fastener or the one that hasn't been invented, Southco is well qualified to invite your inquiries. There's no obligation on your part. It's part of our business to offer free consultation at the design or production levels, on items of your own product line, or on those involving military specifications.

Send for your complete Southco Fastener Handbook, just printed. Write to Southco Division, South Chester Corporation, 236 Industrial Highway, Lester, Pa.

* *Reprints of this page are available on request.*

SOUTHCO FASTENERS

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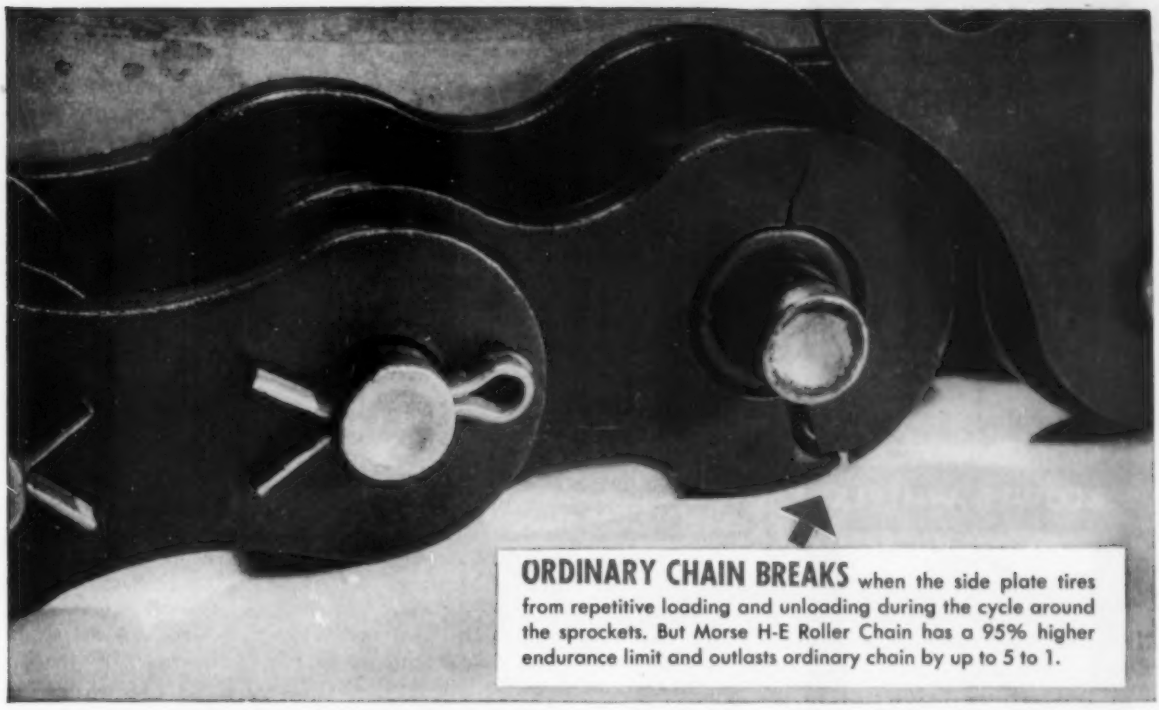


ORDINARY CHAIN BREAKS when the side plate tires from repetitive loading and unloading during the cycle around the sprockets. But Morse H-E Roller Chain has a 95% higher endurance limit and outlasts ordinary chain by up to 5 to 1.

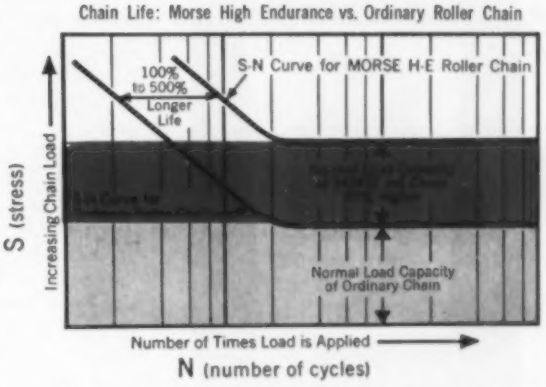
"Tired Metal"... the bane of chain now licked by MORSE H-E

Morse H-E Roller Chain has up to 500% longer service life . . . cuts replacement and labor costs

The unretouched photograph shows what happens to chain when the metal fatigues. But now a special Morse process has licked the "tired metal" problem. It gives Morse H-E Roller Chain 95% higher endurance limit . . . and up to 500% longer service life.

The special process means Morse H-E Chain costs about 10% more. But that's a small price to pay for a heavy-duty chain that can save you thousands of dollars annually in replacement costs, downtime, and wasted man-hours.

For more information on the chain that licked the "tired metal" problem once and for all, see your local Morse Distributor. Or write: MORSE CHAIN COMPANY, Dept. 4-39, Ithaca, New York. Export Sales: Borg-Warner International, Chicago 3, Illinois.


Chain Life: Morse High Endurance vs. Ordinary Roller Chain
S-N Curve for MORSE H-E Roller Chain
100% to 500% Longer Life
Normal Load Capacity of Ordinary Chain
S (stress)
Increasing Chain Load
Number of Times Load is Applied
N (number of cycles)

Red area: Under these chain loads, fatigue will break ordinary chain . . . but *not* Morse H-E.

White area: Under these loads, fatigue will break ordinary chain and Morse H-E . . . but Morse H-E will have operated 100% to 500% longer.

MORSE *Trademark

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A BORG-WARNER INDUSTRY

REMEMBER: Only Morse offers you all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belts.

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SOUTHCO FASTENERS

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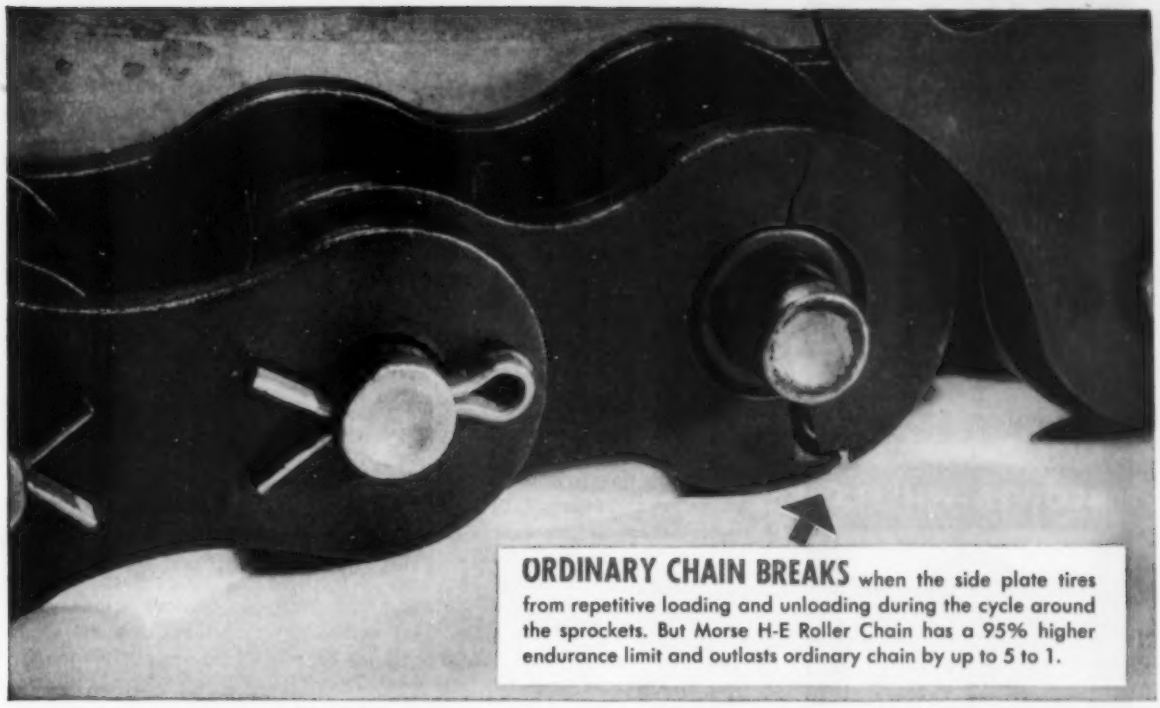

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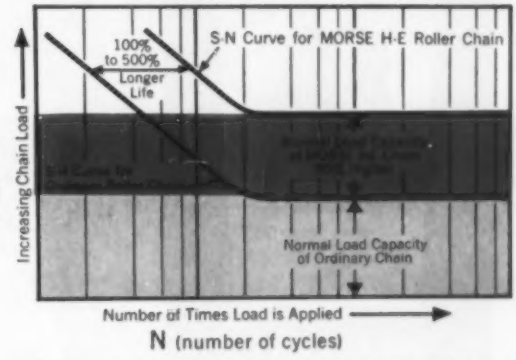
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REMEMBER: Only Morse offers you all four of these basic drives: Roller Chain, Silent Chain, Hy-Vo®, and "Timing"® Belts.

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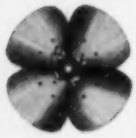

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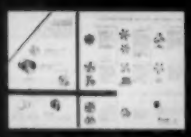

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Tangents...

"Mene, Mene, Tekel Upharsin"

These words, written by the fingers of a man's hand on the wall of Belshazzar's banquet hall, spelled out his fate when the king of Babylon served impious wine in captured vessels from the temples of Jerusalem. Daniel the prophet read them as: *Mene:* "God hath numbered thy kingdom and finished it." *Tekel:* Thou art weighed in the balances, and art found wanting. *Peres* (root of Upharsin): "Thy kingdom is divided, and given to the Medes and Persians." **That same night, Belshazzar was slain, and Darius, the Medean, took the kingdom.**

Scientists and engineers today are reading the handwriting on the wall. (They read it before Sputnik I, but nobody listened.) But, 16 months after Sputnik, the shock has worn off; we're settling back into a luxurious apathy that even Lunik (really *Mechta*, or dream, in Russian) couldn't shake. The layman is very much interested in Soviet Russia still, but has rationalized himself—or been lulled—back into our pre-Sputnik feeling of superiority.

The handwriting sets the target date at 1970. USSR officials have said again that when the current 7-year plan is completed, surpassing the US in output per capita is only five years away.

Consider for the moment that in 1917, the Soviet Union produced less than 3% of the world's output. In 1937, the figure was still only 10%. In 1958, it was 20%, despite losses and delay of World War II. The US figure is about half the Western World's total—or about a third of the world total. **According to Soviet figures, industrial production in the USSR increased 16% annually from 1930 to 1957, while US production increase averaged 2.7%.** Even allowing for the high rates of growth in the first years of Soviet development and the postwar acceleration, these are startling figures. In recent years, Soviet production has increased annually 10 to 11%, and the 7-year plan sets a goal of only 8.6%. **But this is more than three times our figures, and the next seven years are expected to show a doubling in metalworking and machine building as a result of numerical control and transfer machines.**

Dr. A. Arakelyan, Soviet economist, claims present Soviet production is now 36 times that of pre-revolutionary Russia, with the emphasis on engineering capital equipment. The 1957 output in metalworking and machine building was 200 times the 1913 level, and there was 108 times as much electrical power available. (To stress the emphasis, compare this with a 10 times over-all increase in production.) Some 4500 types of machinery and 800 types of instruments have been designed and put into production in the past five years. **Current output of engineers is three times ours and about to become four, scientists two to one.** Some 7.5-million college graduates and technicians are now employed, 39 times the 1913 figure.

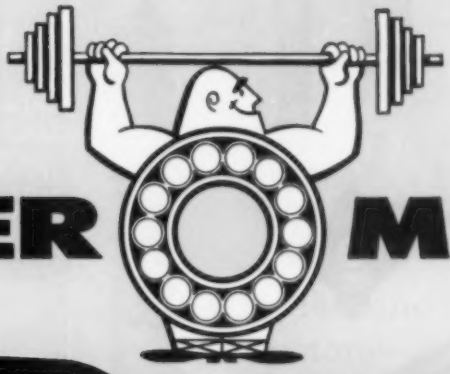
The largest steel plants—Magnitogorsk, Kuznetsk, Nizhni-Tagil and Dzerzhinsky—are to be automated, and are expected to pay out in two years. A million tractors and 400,000 grain harvester will be produced to help mechanize agriculture. A 600,000-kw nuclear-power station is to be built; 100,000 kw of it is already working. A new reactor type is to be built on the Volga. Productivity per worker is to rise 45 to 50% in industry, 60 to 65% in construction, 100% on collective farms.

Thermal power, rather than hydroelectric, is being stressed—it can be built faster. 1958 power generation was 233,000-million kwhr, 81% by steam, 19% by hydro, indicating a 230% increase from 1957 and making the Soviet Union the World's second largest power producer. Steam stations increased 24.5-million kw, hydro stations 7.4-million. This rate of increase will be doubled in the next seven years. The 35,000-volt transmission lines will total 100,000 km by the end of this year, and will be doubled or tripled in the next six years. Some 20,000 km of railway are to be electrified and 400,000-volt grids are to tie in the south with the other areas.

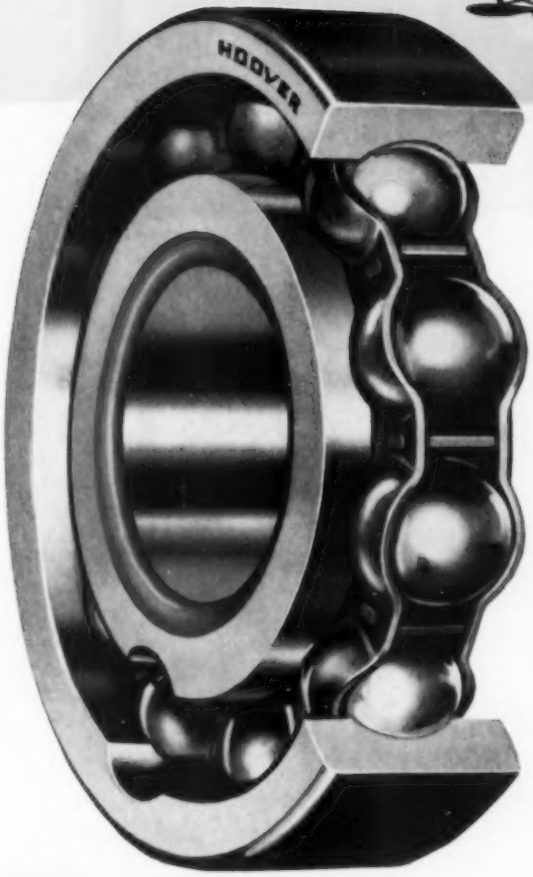
These figures are listed merely to support the point that it is not transi-

(Continued on page 108)

hoover introduces



"SUPER MAX"



Maximum Capacity Ball Bearings of Outstanding Quality

Hoover has designed "Super Max" bearings to provide the greatest radial capacity that can be efficiently obtained in a single row ball bearing. These durable bearings utilize the maximum number of extra-large-size balls that can be introduced into the bearing, giving optimum load-carrying ability. In addition, the smoothness of *Hoover Honed* raceways and the perfect matching of *Micro-Velvet* balls, accurate within millionths of an inch, contribute to exceptional load-carrying capacity.

Hoover "Super Max" bearings are recommended for applications requiring extended life under relatively heavy radial loads. They are available in open and shielded types, with or without snap ring, to meet maximum capacity requirements.

Hoover Honed, *Micro-Velvet* and *"Super Max"* are Hoover trademarks.

hoover

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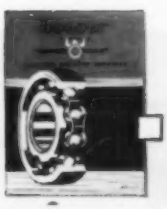
5400 South State Road, Ann Arbor, Michigan

Los Angeles Sales Office and Warehouse:
2020 South Figueroa, Los Angeles 7, California



FREE LITERATURE

Check the information you want.

☐ BULLETIN 107 gives complete data on "Super Max" bearings.

☐ HOOVER HANDI-BOOK of Anti-Friction Bearings outlines bearing types, problems, applications.

PE-3

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New ALLEN-BRADLEY OILTIGHT PRESSURE SWITCHES

Bulletin 836 Type T

Both operating pressure and differential are adjustable on these new A-B oiltight pressure switches. Operating pressure is externally adjustable, and setting shows on calibrated scale. A trip indicator shows operating point.

For machine tool hydraulic systems—operating at pressures up to 5,000 psi

Especially designed for heavy duty industrial applications, these new Allen-Bradley oiltight high pressure switches assure long, trouble free life. The attractive die-cast aluminum enclosure is completely sealed to exclude oil and water. The snap-action switch mechanism maintains its high contact pressure to the point of switchover—no matter how slowly it is approached. Contact chatter is eliminated—trouble free contact life is increased. The contact block has two isolated circuits with one N.O. and one N.C. set of contacts.

Send for complete information on this newest addition to Allen-Bradley's wide line of *quality* pilot controls.

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A-B QUALITY

Internal view of piston design used on units for systems above 500 psi. Bellows type construction is used up to 500 psi.

Also...A New Line of Pressure and Temperature Controls with Lower Differentials

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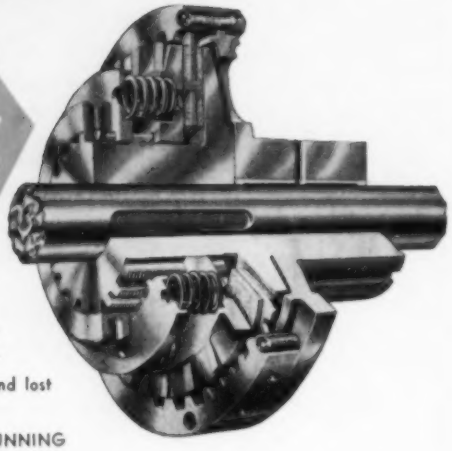
Bulletin 836 Type A pressure control with new bellows that provide ten times longer life. Operating ranges up to 900 psi.

HILLIARD *Clutches*
FOR POWER CONTROL DESIGN

ADJUSTABLE *Slip Clutch*



- PROTECTS against overload, jams and down time.
- RESUMES THE DRIVE AUTOMATICALLY after overload.
- ELIMINATES SHEAR PINS and lost time.
- ADJUSTABLE - WHILE - RUNNING feature is available.

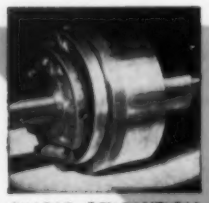
Hilliard Slip Clutches are continuously protecting the drive on dish washing machines—printing presses—packaging machines—case loaders—foundry equipment— air filters—conveyors—overhead doors—and many others.
They maintain steady torque while permitting speed variation on fabric drying drums, steel strip slitters and similar equipment.

The adjustable-while-running types are used to maintain constant tension on rewind stands for paper coaters, textile machines, rope, steel and wire mills and for drive systems requiring overload protection but which must be disconnected at times.

WRITE TODAY FOR BULLETIN 300 WITH COMPLETE INFORMATION.

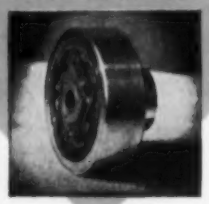
● OTHER HILLIARD CLUTCHES ●

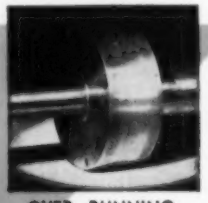
CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS



SINGLE REVOLUTION CLUTCHES for automatic accurate control—electrical or mechanical—of intermittent motion, indexing, cycling and cut-off. Ask for Bulletin 239.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.





OVER - RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet, or backstop action. Ask for Bulletin 231.

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ent triumphs like the Sputnik and the Lunik that should have our attention, but **the long-term acceleration of Soviet engineering and production.**

Among the many evidences that the Russians have the long-term goals in mind are recent reports on scientific developments. Russia already has the world's most powerful atom smasher (Dubna), rated at 10-billion electron-volts and utilizing 36,000 tons of steel, the first atomic ice-breaker, the first twin-jet passenger transport, the first ICBM, portable H-bomb, and peaceful nuclear power plant. She is planning the world's largest telescope, largest solar power plant, and largest neutron-producing reactor. She is well ahead on polar and oceanographic research, has the largest hydro plant (Volga) and biggest new oil field. **She is producing five times our 600 metallurgists a year, 150 times our three geodesists.** Victor Cohn recently reported the USSR has 12 Arctic search parties to our two, a non-magnetic research ship, 18 oceanographic research ships (two over 10,000 tons) to our two converted yachts. He also suggested she may be ahead of us in theory in geology, weather control, mathematics, solid-state physics, cryogenics, arctic air defense, astronomy, but not in industrial chemistry, electronics (and hydraulics, I would add).

These are all interpretations of the handwriting on the wall. Belshazzar couldn't read it—and had it interpreted too late, despite the opportunity he had to profit from the fate of his father, Nebuchadnezzar. Are we collectively playing Belshazzar?

Some of our public voices promote for president a man who had eight hours of conversation with Khrushchev, political advantages currently seems to be more important than scientific planning, than stripping down to essentials for the coming economic race. It seems more important to express our displeasure by being discourteous to Mikoyan than to concentrate on efficiency in government allocation of funds. We're still, as a nation, worrying about today, chopping up a development program to get something—anything—into the sky to save our collective face. The USSR, however, is playing for the long pull—for a decade from now. Her engineers and ours both know the game is for keeps. Can we get this idea across to the American public? —EJT

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CIRCLE 163 READER SERVICE CARD

"YOUR NEXT POLYESTER COMPONENT:
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Giving the designer facts to help make the *right* design decision faster is perhaps our best "product." Offering the broadest line of plastic materials and services permits us to give impartial help. Take polyester glass mat.

If the facts about configuration, volume, performance, operating conditions and cost point to a *molded* polyester shape, we'll work from scratch—or from your drawings—and deliver 100% usable parts.

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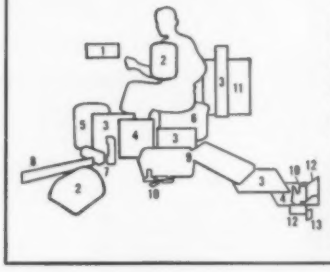
One more point. The problems inherent in machining polyester glass laminates have had a tendency to discourage some designers from considering it. We suggest that you bounce this headache out of your production facilities and into ours.

You see, we are interested in *both* your design and machining problems. Your component will be skillfully machined at one of our four complete, "service-located" fabricating facilities.

Send for our Polyester Technical Bulletin 1164. We'll be happy to include, also, data on the full line of National materials—over 100 grades. Write to National Vulcanized Fibre Co., Dept. H-3, Wilmington 99, Delaware.



1. Silk screened sign, polyester sheet. **2.** Molded weldor's helmets. **3.** Polyester sheet, natural. **4.** Polyester sheet, black. **5.** Molded radome cover for traffic radar detector. **6.** Molded explosive powder bucket. **7.** Molded photographic film splicer housing. **8.** Machined circuit breaker support bar. **9** Molded tray & lid. **10.** Punched terminal boards. **11.** Molded bread tray. **12.** Punched electric arc suppressor. **13.** Machined cam block.

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PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, TEFLON, or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

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PHENOLITE Copper-Clad Laminates: 10 standard grades.

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DESIGN ABSTRACTS

SPE Annual Technical Conference, Jan. 27-30

For copies of papers: SPE, 65 Prospect St, Stamford, Conn

Reinforcement

Phenomena of fiber-resin laminate systems are discussed and compared with other reinforcement techniques. A discussion of fibers, adhesions and the characteristics of fiber-resin material failures is included.

"Reinforcement," Amidors and Goldfinger, Naugatuck Chemical, Div US Rubber Co; SPE paper 37.

Plastics—Hardness, Abrasion, Wear Resistance

Equipment and techniques for hardness measurement and evaluation of abrasion and wear resistance are compared.

"Critical Review of Methods of Determining Hardness, Abrasion and Wear Resistance of Plastics," L Boor, Philadelphia Quartermaster Depot; SPE paper 61.

Measuring Flammability of Plastics

Usefulness and limitations of various flammability tests are discussed, particularly those involving fire hazards.

"Critical Review of Methods for Measuring Flammability of Plastics," Sauber and Patten, Dow Chemical Co; SPE paper 63.

Hi-temp Properties of Reinforced Plastics

Five testing procedures for determining elevated-temperature design data are described. Evaluation procedures for determination of such phenomena as ablation at transient temperatures as high as 20,000 F.

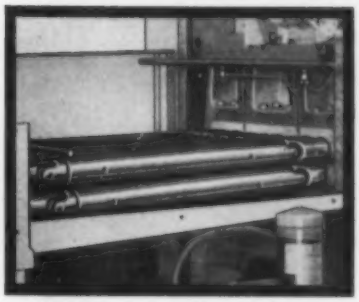
"Critical Review of Methods for Determining Properties of Reinforced Plastics at Elevated Temperatures," Peterson and Schmidt, Wright Air Development Center; SPE paper 64.

Effect of Sleeve Material on Fatigue Strength of Shafts

Pronounced differences in fatigue strength of shafts carrying pressed-on sleeve components have been ascribed mainly to fretting corrosion previously. For example, hardened-steel on carbon-steel shafts have reduced endurance limit up to 47% of the base shaft. A series of tests wherein split sleeves

(Continued on page 115)

HOW CURTIS SOLVED A CLOSE CENTER-TO-CENTER PROBLEM



The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

The answer was a Curtis universal joint! The maximum load carrying capacity and minimum torsional deflection of the Curtis joint was found to be completely satisfactory. And Curtis' famous Telltale Lock Ring construction permits quick disassembly for easier maintenance.

This is just one of the many power transmission problems solved by Curtis universal joints — size for size the *strongest* universal joints designed for industry. Selected materials, precision engineering, and 40 years' experience manufacturing universal joints exclusively make them that way.

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DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with ***FLEXIBLE SHAFTS***

Light Weight and handling ease are two obvious advantages this flexible shaft driven concrete grinder has over conventional portable tool design. Weight of the motor is removed from the operator's hands. S.S.WHITE power drive flexible shafts are ideal whenever there is relative movement between the driven and driving part.

STANDARD S.S.WHITE FLEXIBLE SHAFTS are available "off the shelf" to allow the designer to test the advantages of flexible shafts at low cost. For complete information, write for Bulletin 5801.

S.S.WHITE also offers engineering service and a comprehensive selection of *flexible shaft* sizes and types to meet specialized design requirements. Complete information in Bulletin No. 5601.

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FIRST NAME IN FLEXIBLE SHAFTS

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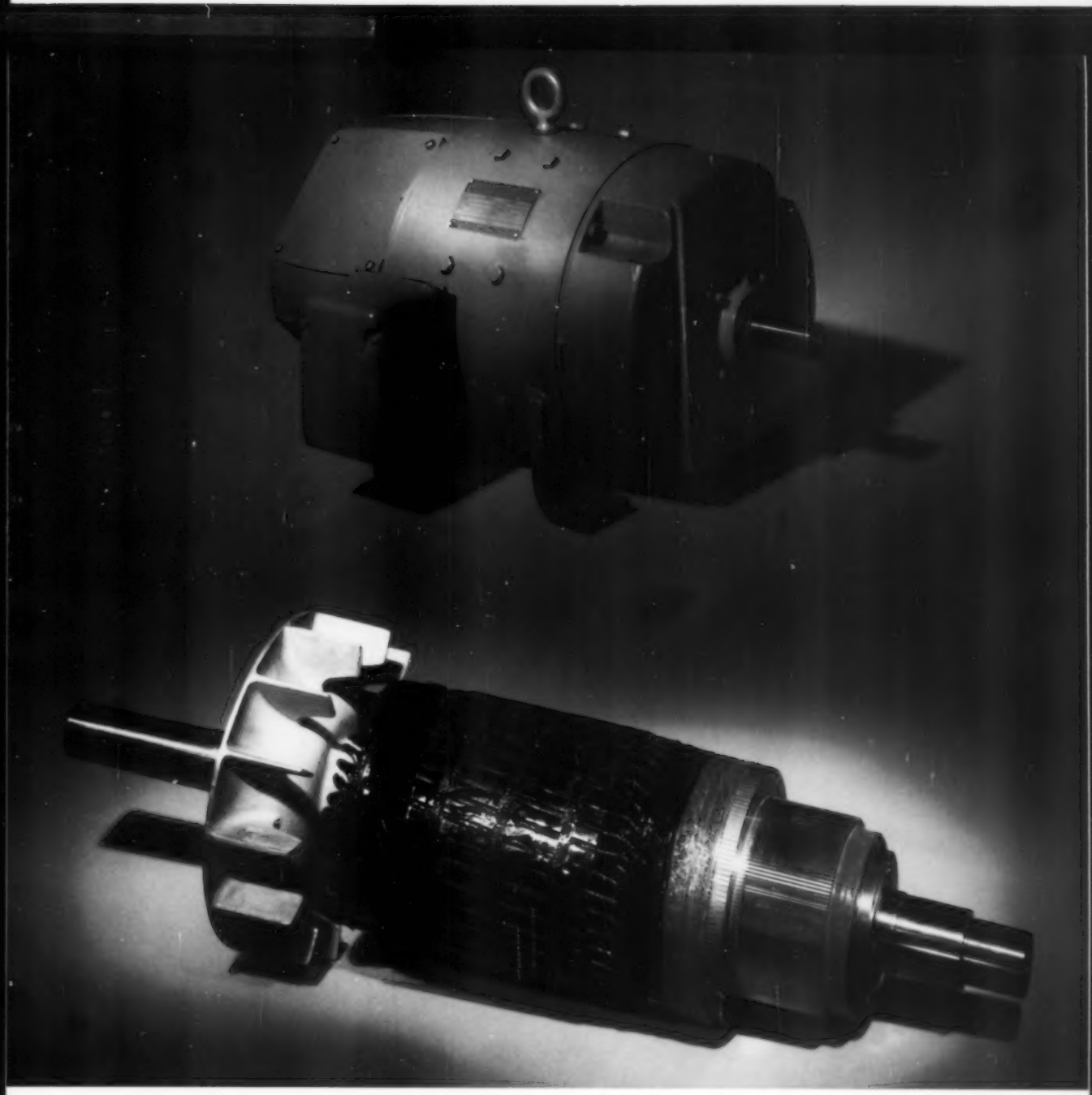
Position Controls To Best Advantage by using S.S.WHITE remote control flexible shafts, as on this fractional horsepower variable speed electric motor. The shaft transmits changes in the setting of the control handle to the motor to allow exact speed changes while motor is in operation. It eliminates alignment problems, reduces number of parts required, saves time and cost in assembly and is adaptable to any number of special motor applications.

Key To universal flexibility of this handy drill unit is a ¼" S.S.WHITE flexible coupling shaft with drill collet attached. Use of the flexible shaft coupling makes unit compact, light and easy to handle. Coupling shafts — flexible shafts without companion casings — meet a wide variety of control and power drive applications. (Dept. 14)

Useful data on how to select and apply flexible shafts! Write for Bulletin 5601.



NEW GENERAL ELECTRIC DC MOTOR GIVES

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KINAMATIC* . . . a new standard in industrial direct current motors . . . designed to deliver drive power at the moment you need it!

Split-Second Response . . . larger air gaps reduce electrical time constants . . . smaller armature diameter permits more rapid delivery of torque to load . . . means faster starts, stops, reversals.

Low Inertia Armature is dynamically balanced, banded with steel and glass . . . gives dependable, high-speed operation . . . skewed armature slots minimize torque pulsation, permit smooth machine operation at low speed.

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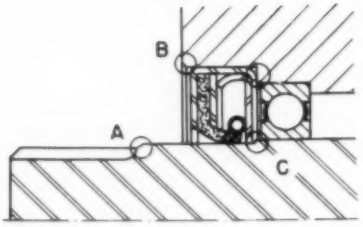
NATIONAL® OIL SEAL LOGBOOK

4 common shaft sealing conditions

. . . and engineering tips that can help you "design-in" better oil seal performance

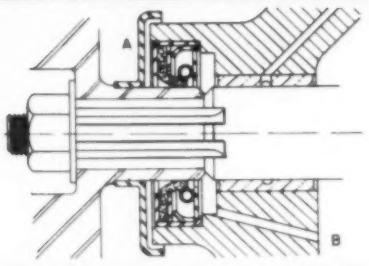
CONVENTIONAL INSTALLATION

Here a standard-design single lip seal retains lubricant and excludes normal dirt, dust and moisture. Sealing lip points in since seal's principal job is retaining oil or grease around bearing. Note that shaft is stepped and chamfered at "A" to prevent damage to sealing lip during installation. At "B", bore is chamfered to facilitate seal entry. At "C", counterboring insures accurate positioning of the seal.



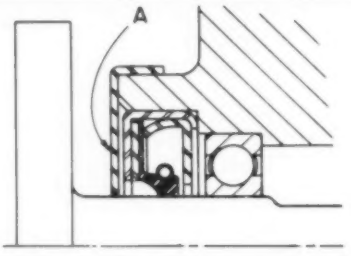
HEAVY DIRT CONDITIONS

Here is a commonly used method of protecting the seal and increasing seal life on applications subjected to extreme dirt conditions. The guard baffle at "A" is welded or swaged to the wheel hub to exclude the major portion of dirt and dust. The drain hole at "B" relieves pressure at the sealing point. In addition to the guard baffle, many manufacturers employ a dual-lip seal to insure bearing protection under extreme dirt conditions.



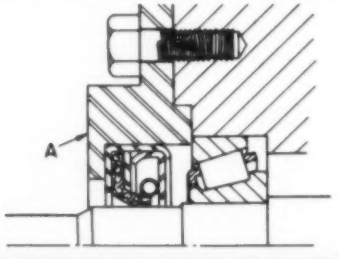
SEALING LONG, HEAVY SHAFT

Many cases of so-called "seal failure" are due solely to poor installation techniques. While today's seals are rugged, they can be rendered non-serviceable if distorted out of round, cocked in the bore, or if the sealing lip is torn. To protect the seal against such physical damage during installation involving a long shaft, a seal protector as shown at "A" may be mounted on the hub O.D.



INSUFFICIENT DEPTH TO MOUNT SEAL

Where the housing does not provide sufficient depth for counterboring, or where seal installation would be difficult or likely to damage the seal, a separate mounting member ("A") can be employed. As before, the shaft should be chamfered to prevent damage to the sealing lip during installation.



NATIONAL SEAL
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General Offices: Redwood City, California
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Van Wert, Ohio

5207

were pressed on 0.45% carbon-steel shafts by a collet-type fitting indicated a reduction of about 50% of base shaft regardless of sleeve material or hardness. This reduction does not occur in rolled shafts, nor in those ground after rolling.

"Effect of the Material of an Enveloping Sleeve on Fatigue Strength of Axles and Shafts," Kudryavtsev and Savvina, Vestnik Machinostroyenya, Vol 36, No 7, Moscow, USSR.

Five on Reinforced Plastics

Two of the papers presented at the 14th Annual Meeting of Reinforced Plastics Div, Society of the Plastics Industry (250 Park Avenue, NYC) which took place Feb 3-5, described nondestructive testing procedures and equipment. These papers were "Nondestructive Quality Control Tests on Finished Reinforced Plastic Parts," A D Coggeshall, General Electric Co, and "Study of Toughness of Polyester Resins," H S Lovelace, American Cyanamid Co.

"Effect of Long-term Loading on Glass-reinforced Plastic Laminates," K H Boller, Dept of Agriculture, reports on an investigation of stress-rupture and creep characteristics of several glass fiber-reinforced laminates.

"Epoxy Laminates Under Stress in Chemical Solutions," Delmonte and Sarna, Furane Plastics Inc, describes tests of 8-ply glass cloth laminates in various epoxy resins under stress in hot water. Different results for different materials were obtained and the higher heat distortion temperatures noted in some cases are considered good criteria of chemical resistance under stress.

"On the Flexural Failure of Cloth-reinforced Laminates," J O Outwater, University of Vermont, describes two distinct types of flexural failure: (1) the surface under compression delaminates; (2) surface under tensile loading fails in tension. Geometrical parameters required in the design of cloth for optimum compressive characteristics are discussed.

Analysis of Lubrication Deposits

Analytical techniques for separating and identifying components of a deposit are described. Several case histories indicating usefulness of such analysis in solving a number of lubrication problems are presented.

"Analysis of Deposits," Lubrication, Jan 59; Texas Co, 135 E 42nd St, NY 17.

Comments of regular users of HUCK FASTENERS tell the story.

"70% saving in our assembly cost".

"50% faster than previous methods".

"We use them wherever possible because of their strength and sealing qualities".

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"They don't slip, strip or wear loose".

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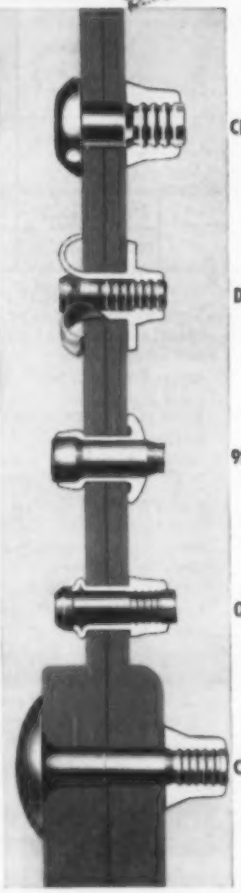

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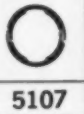
function		for axial assembly				for taking up end-play					
						axial assembly				radial assembly	
nomenclature		basic		inverted		bowed		beveled		prong-lock®	bowed e-ring
series no.		5000	5100	5008	5108	5001	5101	5002	5102	5139	5131
application		Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	Internal for Housing Bores	External for Shafts	External for Shafts	External for Shafts
range	in.	.250-10.0	.125-10.0	.750-4.0	.500-4.0	.250-1.456	.188-1.438	1.0-10.0	1.0-10.0	.094-.438	.110-1.375
	mm.	6.4-253.8	3.2-253.8	19.0-101.5	12.7-101.5	6.4-37.0	4.8-36.5	25.4-253.8	25.4-253.8	2.4-11.1	2.8-35.0

function		for radial assembly				self-locking types					
nomenclature		crescent®	e-ring	reinforced e-ring	interlocking	circular self-locking			triangular self-locking	triangular nut	grip-ring
											
series no.		5103	5133	5144	5107	5005	5115	5105	5305	5300	5555
application		External for Shafts	External for Shafts	External for Shafts	External for Shafts	Internal for Housing Bores	External for Shafts	External for Shafts	External for Shafts	With Threaded Screw	External for Shafts
range	in.	.125-2.0	.040-1.375	.094-.438	.469-3.375	.312-2.0	.094-1.0	.094-1.0	.062-.437	•	.077-.755
	mm.	3.2-51.0	1.0-35.0	2.4-11.1	11.9-85.7	7.9-50.8	2.4-25.4	2.4-25.4	1.55-11.1	•	•

GENERAL DESIGN PRINCIPLE: Tapered construction permits rings to maintain constant circularity and groove pressure.

Series 5000 and 5100: Basic types for axial installation. Rings provide optimum groove strength.

Series 5008 and 5108: Best clearances. Accommodate parts having large corner radii or chamfers.

Series 5103: Best clearances. Secure against moderate impact, vibration.

Series 5133: Provides high coupling shoulders; accommodates wide groove tolerances. Easy servicing.

Series 5144: Reinforced E-ring. Five times more gripping strength, 50% higher RPM limits than standard E-rings.

Series 5107: High impact resistance; high coupling shoulders. Accommodates extremely high rotation and relative parts rotation.

Series 5001 and 5101: Resilient end-play take-up. Accommodate wide tolerances. Recommended for pre-loading bearings.

Series 5002 and 5102: Rigidly locked end-play take-up. Recommended for locking one race of parallel bearing assemblies.

Series 5139: Rigidly locked into position by protruding locking tabs. Provides high resilient end-play take-up with sliding tabs for uniform flexure. Cannot be forced from groove without destroying ring. Accommodates relative parts rotation. Equally effective with round, square, rectangular or hex shafts.

Series 5131: Provides high take-up. Recommended where clearances are a major problem.

Series 5005, 5115, 5105 and 5305: Prongs dig into shaft, locking rings against movement in one direction.

Series 5300: Spring tension locks parts assembled with threaded screws.

Series 5555: Self-locking against movement in either direction by spring tension. Since no groove is required, ring is adjustable to any position on shaft.

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Waldes Truarc Retaining Rings are modern fasteners that solve a wide variety of design and production problems. Send for your new 24-page Catalog RR 10-58. 9-4

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TRUARC®
RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

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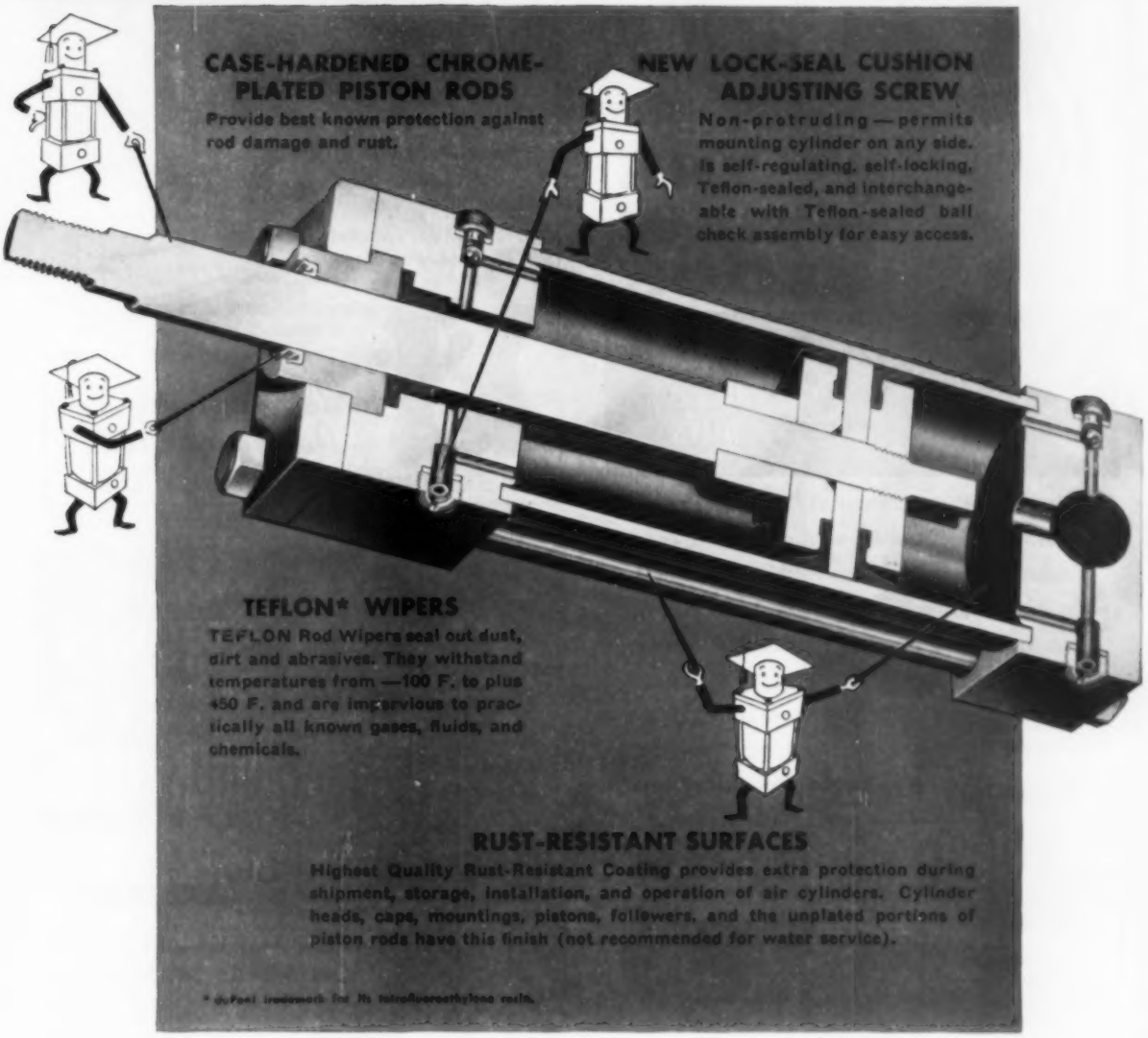
Miller AIR CYLINDERS

with EXTRA QUALITY Features!



CASE-HARDENED CHROME-PLATED PISTON RODS

Provide best known protection against rod damage and rust.

NEW LOCK-SEAL CUSHION ADJUSTING SCREW

Non-protruding — permits mounting cylinder on any side. Is self-regulating, self-locking, Teflon-sealed, and interchangeable with Teflon-sealed ball check assembly for easy access.

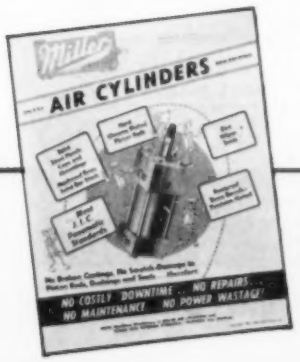
TEFLON* WIPERS

TEFLON Rod Wipers seal out dust, dirt and abrasives. They withstand temperatures from —100 F. to plus 450 F. and are impervious to practically all known gases, fluids, and chemicals.

RUST-RESISTANT SURFACES

Highest Quality Rust-Resistant Coating provides extra protection during shipment, storage, installation, and operation of air cylinders. Cylinder heads, caps, mountings, pistons, followers, and the unplated portions of piston rods have this finish (not recommended for water service).

* duPont trademark for its tetrafluoroethylene resin.



Other Standard Miller Quality Features include: bar stock steel heads, caps, and mountings; rust-resistant brass barrels; self-regulating, wear-compensating piston rod seals that never require adjustment; space-saving square design; and other features as shown in Bulletin A-105 sent free on request.

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Miller Air Cylinders are available in 1½" through 20" bores for 250 psi operation. Select from 19 standard mountings, strokes up to 22 feet, single and double rod end, cushioned and non-cushioned, and over-size rod cylinders. Large selection for immediate delivery.

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DIVISION OF TUCK-REDY CORPORATION

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WIRE FORMS—SPRINGS and METAL STAMPINGS
D-&-B Parts deliver top performance at lower cost! Years of KNOW-HOW and quality control guarantee Wire Forms, Springs and Stampings that are easily assembled . . . withstand stress . . . and perform under the most trying conditions!
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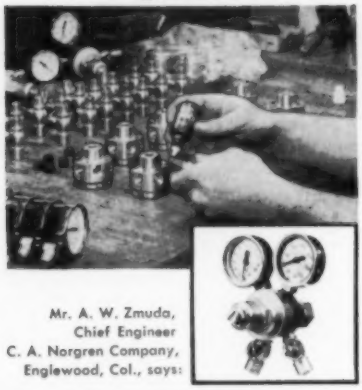
CIRCLE 174 READER SERVICE CARD

CIRCLE 172 READER SERVICE CARD

Loctite seals joints on 3000 psi Gas Pressure Regulators . . .



Mr. A. W. Zmuda, Chief Engineer C. A. Norgren Company, Englewood, Col., says:

"There are three basic requirements for the sealant used in the assembly of our new type 20AN pressure regulators:

1. **It must be a thread seal suitable for high pressure CO_2 up to 3000 psi.**
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LOCTITE fulfills these requirements better than any sealant we tested."

Liquid Loctite hardens between metal parts to form a tough heat and oil-resistant bond completely filling the joint to insure a positive seal. Hardened Loctite is not affected by water, military fuels, hydraulic fluids, degreasing solvents and most chemicals.

Loctite application is suited to mass production . . . requires no heat or mixing. Treated parts can be stored for days . . . lock only when assembled. Any Loctite outside the joint remains liquid and may be wiped off leaving no residue to enter fluid stream.

Loctite seals pipe and tubing joints . . . locks nuts to bolts . . . eliminates need for interference fits for bearings, sleeves, shafts and studs. Write for literature and free sample.

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NEW BOOKS

Fluid Power Controls

J J PIPPENGER, vice pres, Double A Products Co, and RICHARD M KOFF, senior assoc editor, PRODUCT ENGINEERING. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6¼ x 9¼, 252 pp. $9.

Calling fluid power "the most versatile power medium available to the design engineer," these two authors—one a designer of fluid systems, and the other a PRODUCT ENGINEERING editor—have combined their talents to produce a thoroughly practical guide for the selection of control valves. Sixteen chapters cover all available types, telling how they work, how they are combined into a system, what can go wrong.

Approach is practical and functional—material in several of the chapters first appeared in a series of articles in PRODUCT ENGINEERING, authored by Mr. Pippenger and edited by Mr. Koff. Unusual reader interest in the series led to this joint effort of the two authors, which presents practical design guidance on pumps, reservoirs, piping, circuit design, and preventive maintenance—in addition to detail coverage of all types of valves from simple to complex. Appendix includes a glossary, standard graphical symbols, complete text of JIC hydraulic standards, and an index. —RWC

Sale–Leasebacks and Leasing in Real Estate and Equipment Transactions

HARVEY GREENFIELD, Atty, NYC Chairman, Taxation Committee, Federal Bar Assn of NY; NJ, and Conn; and FRANK K GRIESINGER, asst treasurer, Lincoln Electric Co. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 9 x 11, 156 pp. $15.

What should an engineer recommend—purchase or lease?—when his company needs new building or equipment? Should small companies investigate a sale-leaseback transaction when it finds itself short of capital? How can equipment leasing be used by a manufacturer to improve productive capacity? Answers to these questions and their associated tax problems are answered in detail and case histories are outlined. Initially used in

(Continued on page 122)

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AC MOTORS

1/1000 H.P. to 1/25 H.P.

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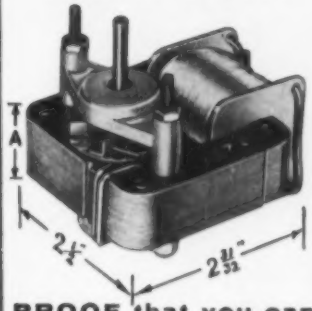

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MODEL "A" two-pole shaded pole motor available in various lamination thicknesses. Precision constructed for reliable, long hard usage. Perfectly balanced for smooth, quiet, operation.

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A-3-CW A-3-CCW	1/500	0.7	1.1	3360	9/16"
A-4-CW A-4-CCW	1/350	1.0	1.4	3380	1/2"
A-5-CW A-5-CCW	1/180	1.7	2.7	3430	9/16"
A-6-CW A-6-CCW	1/130	1.9	3.3	3430	5/8"
A-7-CW A-7-CCW	1/100	2.1	3.8	3500	9/16"
A-8-CW A-8-CCW	1/90	2.5	4.3	3480	1"
A-9-CW A-9-CCW	1/70	2.7	5.3	3520	1 1/16"
A-12-CW A-12-CCW	1/60	3.0	6.5	3500	1 1/16"
A-14-CW A-14-CCW	1/50	3.1	7.0	3490	1 1/16"
A-16-CW A-16-CCW	1/45	4.0	7.5	3490	2"

Standard shaft diameter .1817, 1/4" shaft available if desired.

Write today for catalog sheet and quantity-price quotations.

THE GENERAL INDUSTRIES CO.

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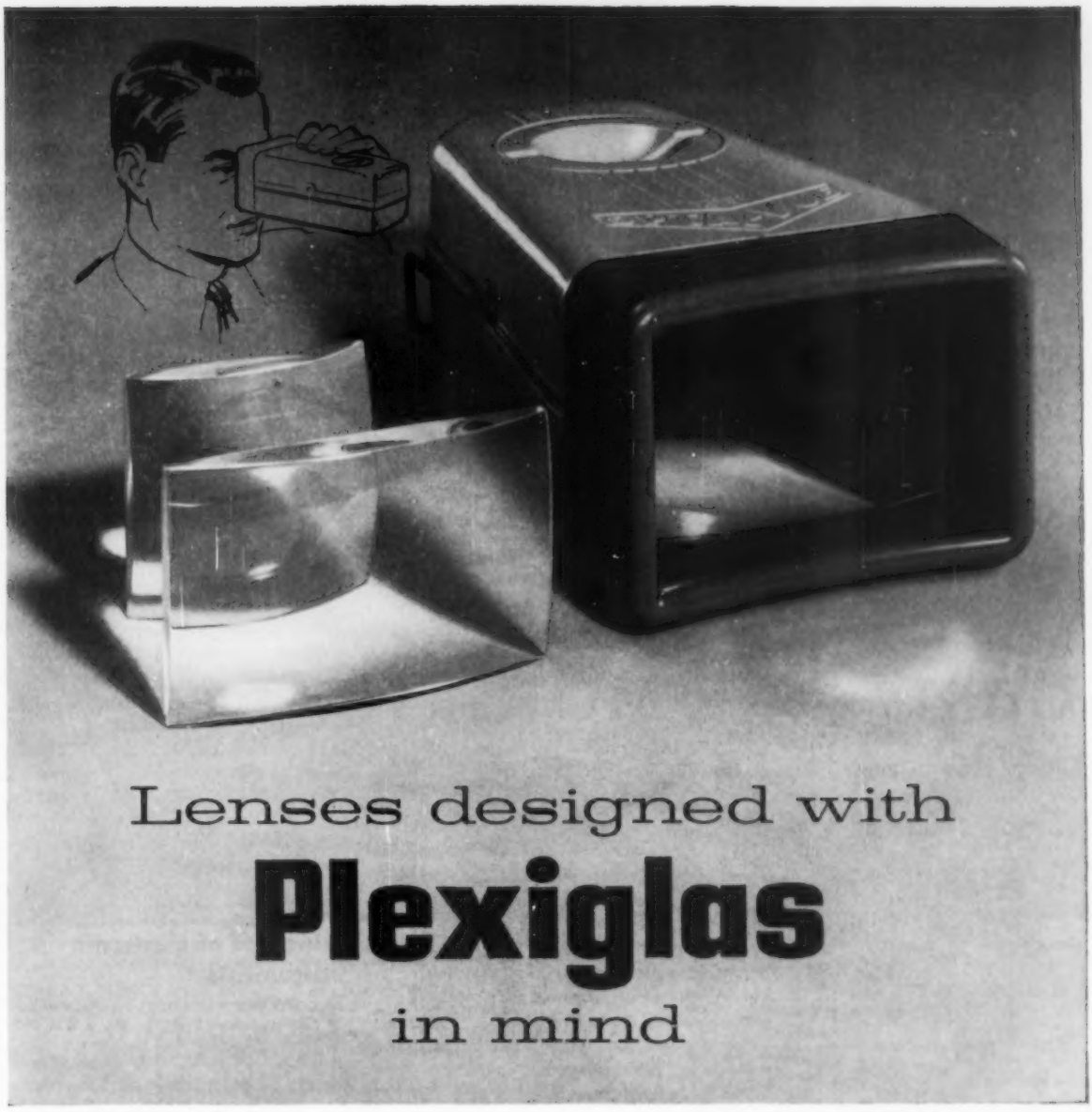

Lenses designed with **Plexiglas** in mind

Problem. Design of a magnifying lens system for 35mm slide viewer*.

Requirements. Five-times enlargement of slide picture with clarity, sharpness and freedom from distortion. Lens system to be resistant to impact if viewer is dropped. Viewer to be priced within range of single-lens units.

Solution. Dual lens system, with lenses molded of optical grade PLEXIGLAS® acrylic plastic. Use of PLEXIGLAS resulted in lenses that give excellent performance and are highly resistant to breakage. Because lenses could be *molded* precisely to fine tolerances, considerable production cost savings were achieved through elimination of lengthy grinding and polishing operations required for glass lenses.

*"Opta-Vue", by Optics Mfg. Corp., Philadelphia 34, Pa.

Examples of fine quality molded parts made of PLEXIGLAS, *in many fields of use, are shown in our full color brochure,* "PLEXIGLAS *for Molded Parts". We will be pleased to send you a copy.*

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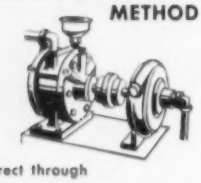
Six sizes . . .
all variable-speed
explosion-proof

GAST rotary vane AIR MOTORS

CHOOSE YOUR DRIVE METHOD



Direct through flexible coupling.

Use gear reducer.

Flange mounted – vertical operation.

Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

GAST MANUFACTURING CORP., P.O. Box 117-V, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

real estate transactions, to make available for operating capital the large sums tied up in plant facilities, the sale-leaseback idea is now being widely used for machinery and equipment. In addition, many manufacturers of heavy industrial equipment are now proposing sale-leaseback as an alternate to outright purchase. The engineer needs to understand these sale-leaseback transactions fully if he is to prepare an economic analysis for equipment replacement or purchase.

Elements of Engineering Statics

H DERESIEWICZ. Columbia University Press, 2960 Broadway, New York 27. 6½ x 9, 124 pp. $3.50.

This is a textbook for a basic one-semester course in statics for all engineering students. The author assumes a working knowledge of elementary differential calculus and the concurrent study of integral calculus. The techniques of vector algebra are employed to develop rigorously the fundamental theorems, results, and methods of statics and to apply these to the solution of engineering problems. The book offers discussions of the equivalence of force systems, the principle of virtual work, and the concept of stability.

Principles of Electronic Instruments

DR GORDON R PARTRIDGE. Prentice-Hall Inc, 70 Fifth Ave, New York 11. 6¼ x 9¼, 393 pp. $11.

Precise measurements of electrical signals hinge critically on how much the experimenter knows about his

(Continued on page 127)

In the vacuum-pourer shown above, the melt is poured into a low-pressure atmosphere in which the molten stream is dispersed—releasing undesirable gases and other substances.

Special alloys, low hydrogen content steels, finished products—available on short notice from Standard

Even in the face of today's extremely critical requirements in metallurgy, Standard Steel Works has maintained its great reputation for quality and service.

With our electric furnace—and the new vacuum-pouring degasser recently placed in operation—we at Standard have facilities in keeping with industry's demands for steel in all applications.

Samples of vacuum-poured steel are tested for gas content in the analytical laboratory apparatus shown above.

Standard Steel Works Division

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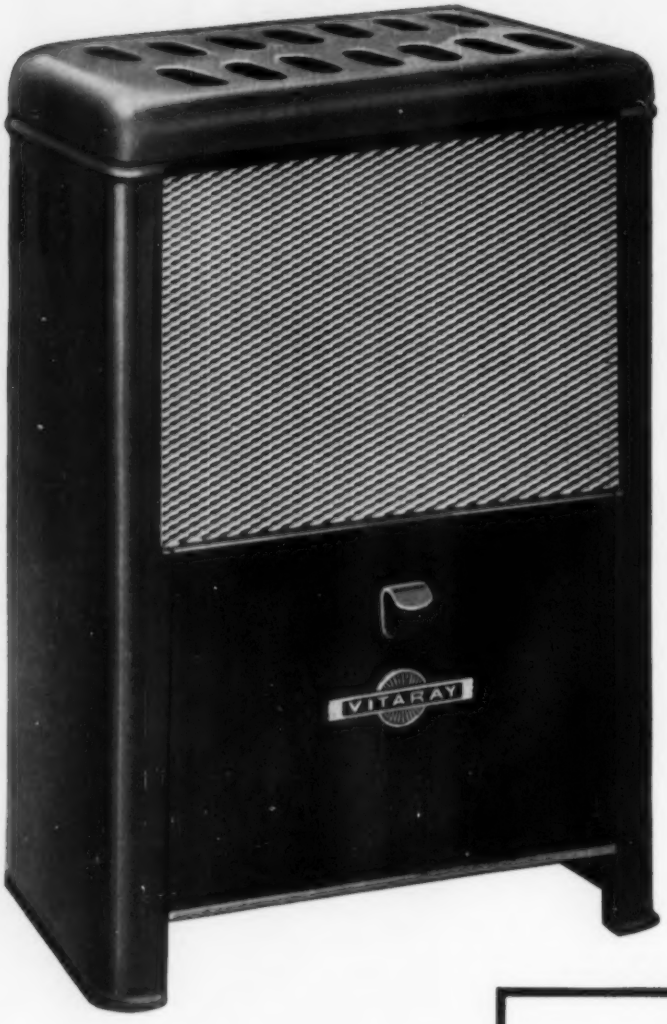
lasting beauty for heaters with aluminum Minimesh grilles



Abundant use of Minimesh enhances the appearance of this gas heater by Quad, Inc., Columbus, Ohio

Quad gas heaters are designed to look attractive and to deliver the heat with top efficiency, year after year. To help meet these objectives, the grilles are made from Penmetal aluminum Minimesh.

The diamond pattern contributes undeniable smartness. Made of anodized aluminum, the grilles will always look new.

Minimesh has the strength to stand up under every-day use; the rigidity to span large areas in an unbroken sweep. Furthermore, the open mesh permits heat to circulate freely.

A grille made from Minimesh is an unmistakable sign of quality. A quality that gives distinction to any product. A quality that changes eyers to buyers.

Folder 510-EM will help you in the selection of Minimesh. Send for a copy today.

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General Sales Office: 40 Central Street, Boston 9, Mass.
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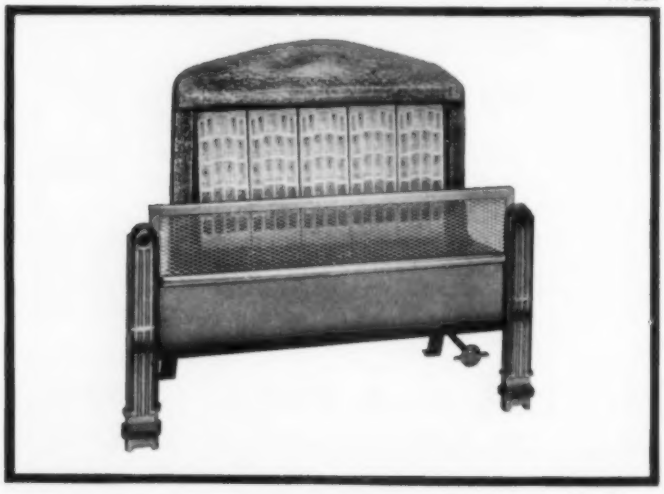
Penmetal
METAL MARK OF QUALITY

a name to remember

PM-205



Another Quad heater featuring Minimesh grille.

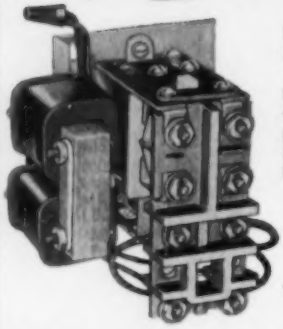
. . . it describes the Vernatherm control and where it is used in a variety of industries. The thermostatic element can lift up to a 250-pound load at temperature ranges from sub-zero to 450°F. Write to Detroit Controls Division of American-Standard, 5900 Trumbull Avenue, Detroit 8, Mich., for bulletin no. 213-A.

American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
DETROIT CONTROLS DIVISION

WARRICK Floatless Electrode Type LIQUID LEVEL CONTROLS . . .

give you all these advantages!



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YOU CAN USE OUR CONTROLS FOR:

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Compact – Quiet – Swift

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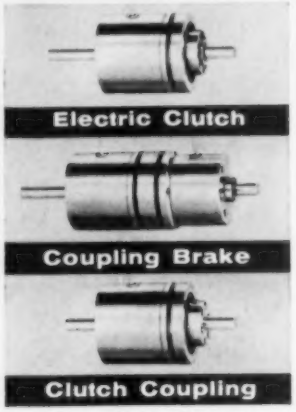
FIXED FIELD ELECTRIC CLUTCHES



Three styles from 7/8" to 3 1/8". Torque output from 10 oz. inches to 100 lb. inches.

In Miniature & Small Sizes

Introduced only a few short months ago, Simplatrol Fixed Field Electric Clutches have found popular application wherever space is tight, noise is objectionable and performance requirements are rigid.

PATENTED DIAPHRAGM ACTION Makes the Difference

No other electric clutch and brake can duplicate the patented Simplatrol diaphragm . . . the only moving part in Simplatrol Fixed Field Clutches. Here is a proved advantage . . . offering an absolute minimum of maintenance.

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Representation in Key Industrial Areas

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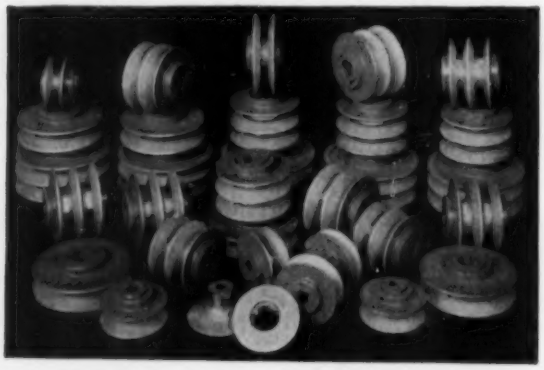
CIRCLE 185 READER SERVICE CARD



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An important preventive maintenance program. The proper frequency of numerals, letters and instruction nameplates for identifying lubrication points and required lubricants on plant, production and operating equipment. Permanent, tough, oil-resistant transfers.

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measuring instruments. Data is no better than the instrument which measures it. Anyone who uses electronic instruments should know something about their frequency response, input impedance, versatility and adaptability to difficult conditions. This book explains operation, gives typical circuit diagrams, and discusses principles and applications in such a way that experimenters can easily design their own special purpose instruments. It is divided into two sections: measurements of electrical quantities by electronic methods, and measurements of nonelectrical quantities by signals from transducers.

Welding Symbols

Prepared by Committee on Nomenclature, Definitions and Symbols, American Welding Society, 33 W 39th St, New York 18. Paperbound, 6 x 9, 88 pp. $3.

The first major changes in welding symbols in recent years are announced in this expanded and improved standard. The number of symbols has been doubled because of new processes and types of welds presently in use. A table shows new system for specifying, by means of letters, 37 commercial welding and cutting processes. And a chart makes all of the welding symbols available to the designer or shop foreman at a glance. Wall-size editions of the chart are also available from AWS at $1.50 per copy.

Elementary Mathematical Programming

ROBERT W METZGER. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 9 x 6, 246 pp. $5.95.

Most material written to date concerning mathematical programming has either been too general to permit any useful study or too highly technical to be understood except by the mathematician. Emphasizing clarity, this book avoids both these extremes and provides an elementary description of several methods of mathematical programming.

Elementary Matrix Algebra

FRANZ E HOHN. Macmillan Co, 60 Fifth Av, New York 11. 8½ x 6½, 305 pp. $10.

The handling of numbers by blocks or matrices is a powerful mathematical tool. This book presents the funda-

(Continued on page 131)

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It was a tough job and "Rush", but now he had it licked. All he needed was the adhesive that would join the rubber component to the metal base. "No problem here," he thought, as he specified the rubber-to-metal formula that had been so successful in a previous job.

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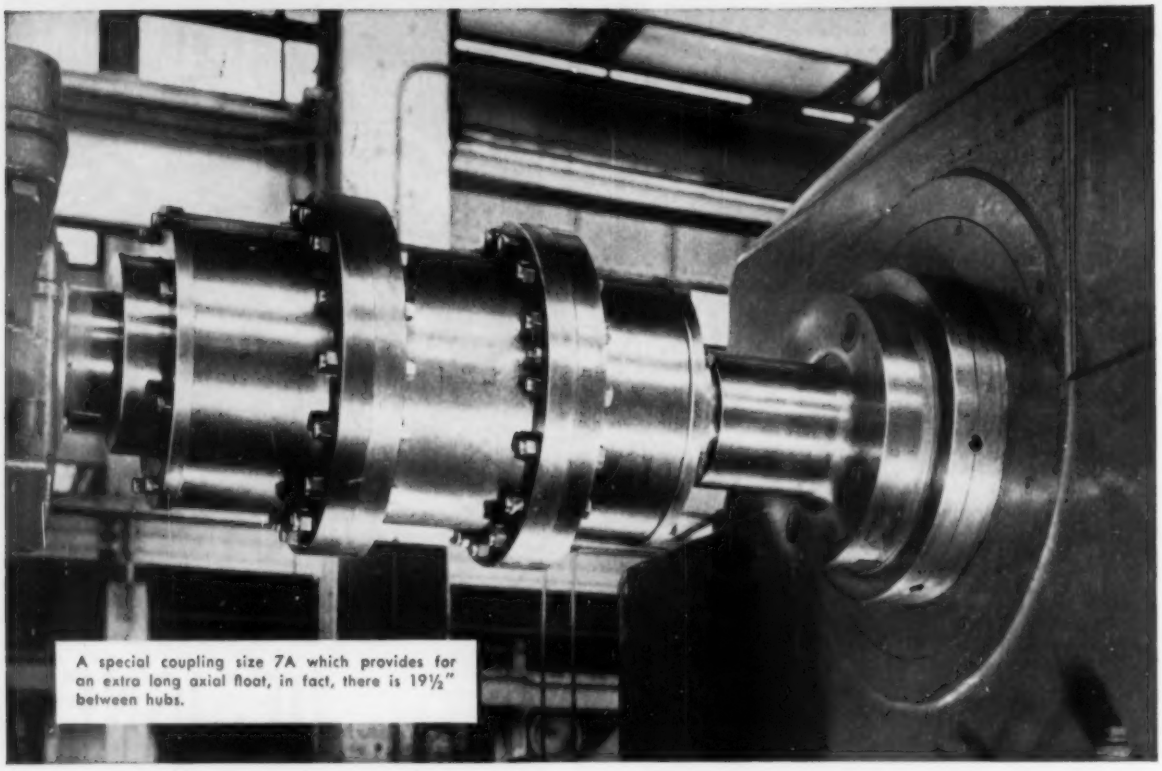

A special coupling size 7A which provides for an extra long axial float, in fact, there is 19½" between hubs.

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From time to time, manufacturers are faced with special power transmission problems which cannot be handled by standard couplings. Sometimes they need a coupling for exceedingly high speed drives, sometimes a coupling for very large diameter shafts and for other special applications.

John Waldron, which is well known for its ability to produce high quality couplings also makes excellent special couplings to customer requirements. In the past, Waldron has made couplings that turn at speeds over 50,000 RPM, couplings which can take over 45,000 HP and couplings for particular applications such as continuous lubricated couplings, spacer types, shear pins, cut-outs and couplings for many other special installations.

If you have a particular power transmission problem that needs a special coupling, call or write the John Waldron Corporation in New Brunswick, New Jersey. Their long experience in designing, and manufacturing couplings for special problems, may have already solved your problem for you.

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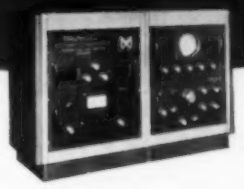
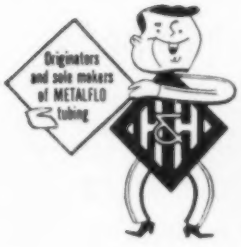


The bright, clean, uniform color of H & H tubing, the burr-free ends tells of quality you can *see*. But today scientific instruments like the Magnaflux unit pictured at the left, watch for tubing imperfections the human eye *can't* see. So if you want tubing that's free of all inclusions, laminations, laps and slivers, tubing that's free of any wavy conditions inside or out, it will pay you to always remember you can *depend* on H & H.



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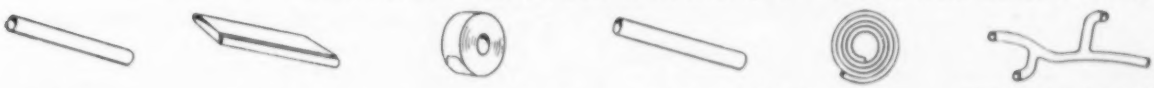

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"Jarvite" high-strength, hard rubber compound performs capably in humid temperatures ranging from 32° to 100° F . . . will not develop soft spots or damage wood floors, unaffected by fats such as shortening, fruit acids, milk acids, flour, etc.

Protective stud cap shields vital grease-packed raceways from steam and hot water . . . ball bearings are packed with high quality, high-low temperature water resistant grease.

Dust and moisture shield protects cup-and-cone wheel bearing assembly from hot water, steam, lint dust, sawdust, threads, etc.

Intermediate raceway is also designed to provide a combination dust guard and moisture shield to protect the lubrication.

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ARE YOUR CASTERS SUBJECTED TO CONDITIONS LIKE THESE?

If so, you can reduce maintenance costs with the J & J Model 5"-48-116 Caster with Jarvite tire. Jarvite withstands heavy loads (up to 1800 lbs.)* without flattening, yet permits smooth movement over fine wood floors without gouging, marking or rutting the surface.

Model 48-116 casters are designed throughout for rugged resistance to adverse conditions, particularly those involving moisture and extremes of temperature. Note the features illustrated at left: your assurance of top performance and long life service.

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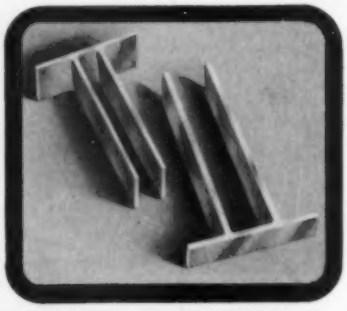

WHITELIGHT more than *doubled* normal limit of tongue ratio*, getting 7 to 1 on this thin gauge aircraft extrusion in ZK60A Alloy.

* *(height of tongue/width —b/e b—3" e—.44" d—1/16" f—90°)*

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mental ideas and methods of this field of matrix algebra in a simple and clear fashion. The worker in any field can learn what he needs to know without difficulty and without the discouraging experience of working through a volume of formal mathematical proofs. This presentation presupposes only a knowledge of elementary college algebra and there is a large collection of examples.

Analog Simulation

WALTER J KARPLUS PhD. McGraw-Hill Book Co, 330 W 42nd St, New York 36. 6 x 9, 404 pp. $10.

This book provides a comprehensive survey of analog techniques and systems for solving field problems. A concise presentation of the mathematical tools necessary for the best use of these techniques is also included.

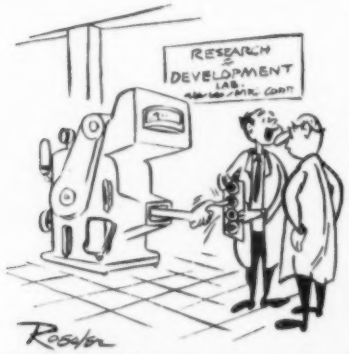
The approach to the subject is unified. The mathematical bridge, linking the characteristic problems of many diverse fields of engineering and physics, is developed early in the text. Examples of the application of electric and nonelectric analog techniques are classified and organized according to the partial differential equations governing the system, rather than the specialized area to which they pertain.

Punched Cards–Second Edition

Edited by CASEY, PERRY, BERRY and KENT. Published by Reinhold Publishing Corp, 430 Park Ave, New York 22. 6½ x 9¼, 678 pp. $15.

It's easier to put information into a system than to get it out again. Punched cards are the modern way of solving this information retrieval prob-

(Continued on page 135)



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Under the Brook O.E.M. Plan you get a better motor to power your product or equipment—yet, this superior motor which ranks with the best under any acceptable standards, actually costs you less than a second rate motor. This saving can be passed along to your customer — if you prefer — thereby lowering the selling price of your product. Everybody benefits! Ask about the BROOK O.E.M. PLAN and what other equipment builders are doing with Brook Motors.

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tiny holes assure pressure tight seals
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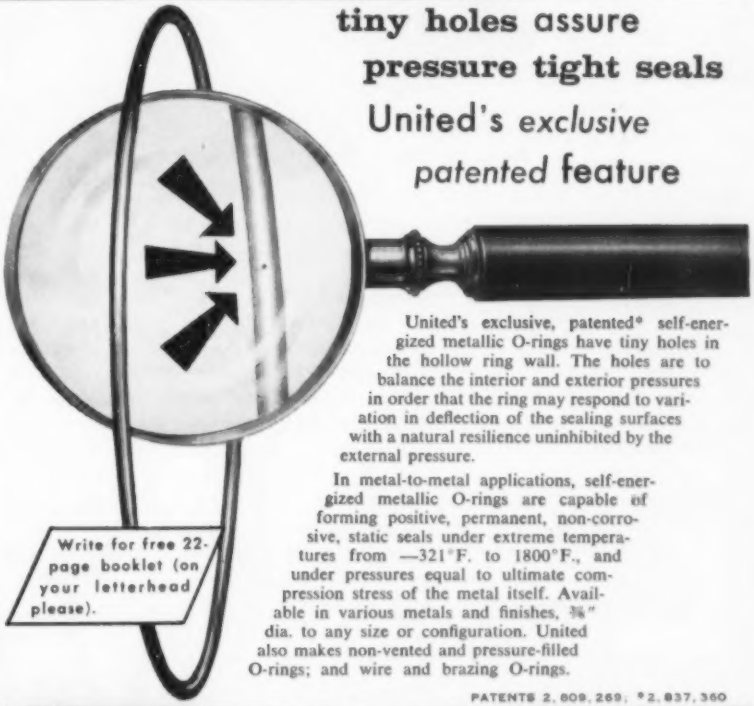

United's exclusive, patented* self-energized metallic O-rings have tiny holes in the hollow ring wall. The holes are to balance the interior and exterior pressures in order that the ring may respond to variation in deflection of the sealing surfaces with a natural resilience uninhibited by the external pressure.

In metal-to-metal applications, self-energized metallic O-rings are capable of forming positive, permanent, non-corrosive, static seals under extreme temperatures from —321°F. to 1800°F., and under pressures equal to ultimate compression stress of the metal itself. Available in various metals and finishes, 3/16" dia. to any size or configuration. United also makes non-vented and pressure-filled O-rings; and wire and brazing O-rings.

Write for free 22-page booklet (on your letterhead please).

PATENTS 2,809,269; *2,837,360

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CONTROL VALVES
reduce assembly and maintenance time

Model PA-121

Built-in plugs and connectors in Valvair's new ¼ in. Speed King 4-way control valves complete electrical circuits *automatically*... reduce assembly and maintenance time to a cost-cutting minimum! Permanent electrical connections are made in manifold or sub-base at assembly... then valves and pilots are plugged in... bolted down. There's no need to disturb equipment wiring for quick in-service maintenance!

Navy M bronze and stainless steel components assure 20 million cycle-plus dependability. Interchangeable pilot, with coil guaranteed against burn-out for life of valve, fits any plug-in Speed King. Coils for ac or dc, any voltage ... 35—200 psi range... optional manual override... ¼ in. cylinder ports... 2 or 3 station manifold with common inlet, exhaust and conduit ports, or sub-base mounted... valve meets JIC standards!

Whether you build or operate machines, you'll find that Valvair plug-in control valves set new standards of adaptability, performance and economy!

Write for Bulletin D-58. Address Dept. PE 359, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio

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electric motion control facts

for IDEA MEN

Electric motion control speeds automatic cycling

This manufacturer set out to design a rugged, dependable machine that would combine simplicity of operation, virtually foolproof electrical control, and flexible setup—for performing a sequence of rapid-fire operations on wire.

Three Warner electric brakes and two electric clutches played an important part in the design of machine elements which automatically measure, cut off, mark, and strip the ends of wire segments used in modern military aircraft and missiles.

Meet maintenance objective

The simplicity with which a series of complex operations could be controlled by electromagnetic rotary drives answered one of the major design requirements—easy maintenance. Use of the Warner units not only eliminated the need for brake and clutch adjustments, it reduced assembly costs, too. And, they provided the ideal answer for controlling fast starts and stops needed in the automatic cycle.

Control spacing to close limits

One step in the cycle is marking the wire at close intervals near both ends and at wider spacings for the rest of the run. Spacing is controlled by two Warner PC-500 feed clutches which engage the fast or slow gear train (see Fig. 2). The end stampings are made as wire moves at 6 in. per sec., with intermediate markings at 30 in. per sec. Fast, precise engagement and release of the clutches easily make extremely close spacings possible.

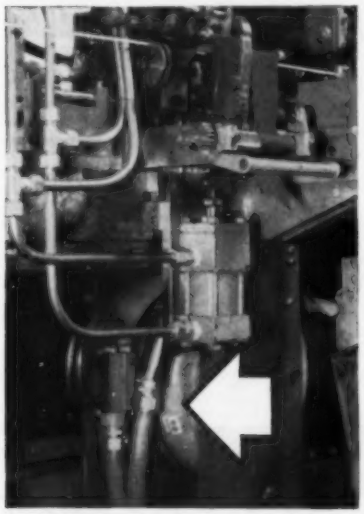

Fig. 1—The transmission that strips and cuts the wire is automatically controlled by the Warner PBC-825 electric clutch-brake.

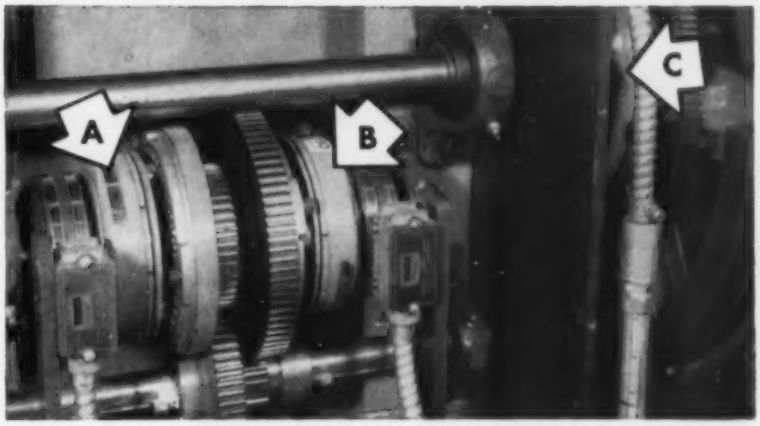

Fig. 2—Two Warner PC-500 electric clutches control wire feed roll. Armatures are mounted on drive pins to special hubs on slow- and fast-feed drive gears. Slow-speed clutch (B) is at the right, and fast-speed clutch (A) is at the left. Warner electric brake (C) assures precise stopping of roll for each index.

Measure wire segments

For cutting wire to accurate segments, a Warner PB-825 electric brake controls the feed roll. This operation is so precise it exceeds the original specifications, measuring segments to a tolerance of plus or minus 1/16 in., even on longer lengths.

The transmission that cuts and strips the wire is actuated by a Warner PCB-825 clutch-brake (Fig. 1) which also actuates the timer and sorter to place wires in the proper slot at the completion of the cycle.

If you have a machine control problem, or want to find out how *electric motion control* can improve performance of your product, talk to your Warner representative or, write for our "IDEA ALBUM" examples of how electric brakes and clutches solved complex motion control problems.

Originators of electric motion control

Warner Electric Brake & Clutch Co.

Beloit, Wisconsin

Please send: ☐ "IDEA ALBUM" Sheets; ☐ Catalog; ☐ Representative.

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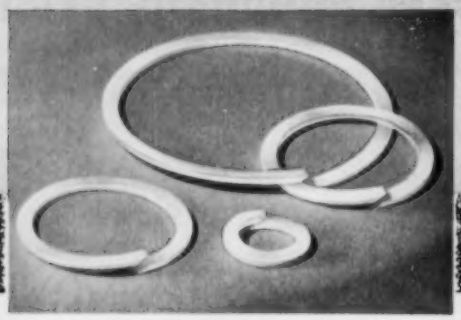

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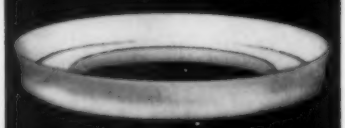

Style 310 Piston Cups

Style 614 V Rings

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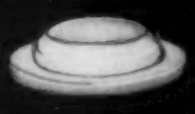

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This is an EXCLUSIVE process which makes the packing lip "remember" the size of the rod or cylinder . . . and keeps it in sealing position, regardless of temperature variations.

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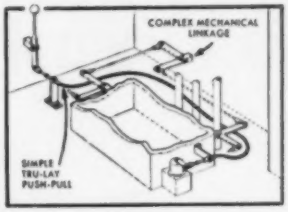
TRU-LAY PUSH-PULL DATA FILE SHOWS HOW TO SIMPLIFY AND IMPROVE DESIGN



Push-Pull remote controls, shown here, are flexible, have but one moving part, and give a lifetime of accuracy. Mechanical linkages are complex, are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.

This Push-Pull Data File—containing 7 engineering bulletins—will show you how these flexible controls have eliminated mechanical linkages on hundreds of products. You can make *your* products more useful, easier to sell, with Push-Pull controls. Write for your Data File today.

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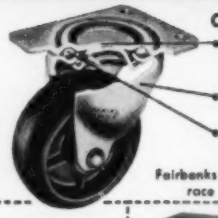
IN CASTER DESIGN
FAIRBANKS
"LOCKWELD" Swivel Casters—Without King-Pin



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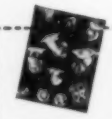

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lem for anyone who must draw from a large collection of facts, figures, things, or ideas. This revised and enlarged edition describes the entire range of cards and equipment, from the smallest system to the largest, both hand and machine-sorted. The editors have written chapters in fields of their specialty; other experts have contributed other chapters, including considerations for adapting punched cards to a system and case histories of actual installations.

Terms and Definitions for the Weighing Industry

Prepared by Terminology Committee, Scale Manufacturers Assn Inc, One Thomas Circle, Washington 5, DC. 6 x 9, paperbound, 98 pp, $1.

Weighing terms and definitions—from accelerating weighbeam to zero notch—are clearly and concisely covered in this offset-printed booklet which also contains a special section on load cell and electronics weighing. It includes a number of idiomatic as well as technical words, defines such common terms as "spring" in relation to their use in scale design.

Effect of Loading Rate on Strength of Single and Multiple Riveted Joints

RICHARD F KLINGER. PB-131513, Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 11, 14 pp. 50¢.

Slow and rapid-loading tensile shear tests were conducted at room temperature on a single and multiple rivet lap and butt joints (WADC report

(Continued on page 139)

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HIGH TORQUE..

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RESISTANCE

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Saving time, labor, weight on tough assembly jobs, these studs make a surprisingly simple operation out of what formerly was accomplished by various slow and costly makeshift assembly methods, such as welding.

You simply place the studs—one or several at a time—into drilled or punched holes in the panel and squeeze them into place with any standard pneumatic or oil-hydraulic squeezer or mechanical press.

The squeezing action embeds the head projections into the sheet—the displaced metal flowing smoothly and evenly around the back-tapered shank and annular groove to securely lock the stud into the panel with high torque and push-out resistance.

Try them. Write for literature and sample. Sizes from #4-40 to 5/16-18. Carbon steel or #305 stainless steel, for use in various aluminum alloys, brass, copper, cold rolled steel and similar sheets in thicknesses from .040 up.

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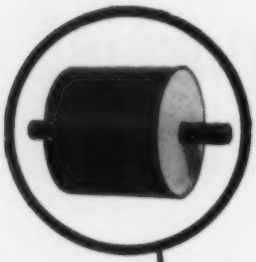
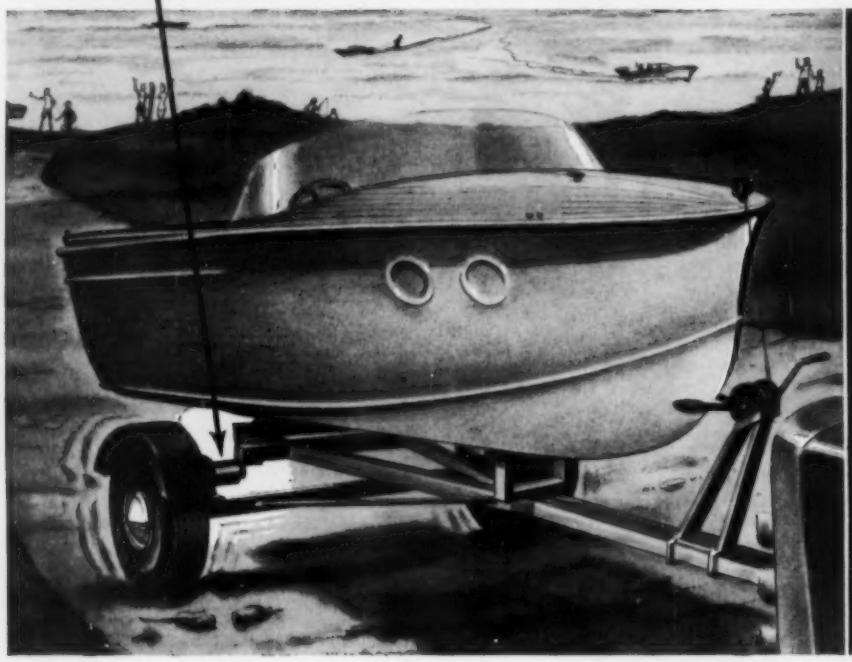


elastomeric springs:

new, low-cost suspension for trailers and light vehicles



Designers can gain cost and performance advantages by using Lord elastomeric springs on

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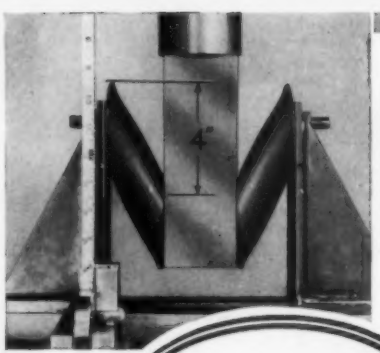
LORD-designed elastomeric springs are used for thru-axle, individual wheel and dual-axle suspensions over a wide load range. Designers can obtain complete information from the nearest Lord Field Engineer or the Home Office, Erie, Pa.



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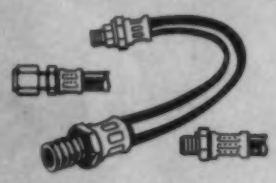

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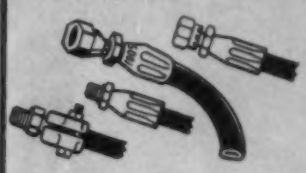

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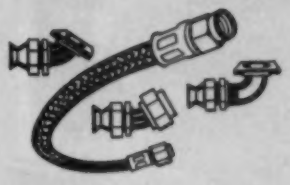

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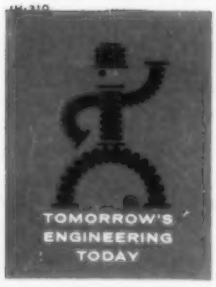

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Current Reprints

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Tabular method simplifies complex design by evaluating integrals. March 16 *Circle E 72*

Motors with Printed-circuit Rotors

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Strain-testing by PhotoStress

Method to read strain in actual structures and parts under load. March 2 *Circle E 70*

Introducing the Space Crank

Variation of a 3-D mechanism that can replace various linkages and cams. March 2 *Circle E 69*

Stress Considerations for Safe Design

Graphical method determines safety factors when fluctuating loads are superposed on existing stresses. Feb 16 *Circle E 68*

When Air is the Coolant

How to estimate whether the assembly will run too hot—and whether or not air can cool it. Feb 16 *Circle E 67*

For Faster Reading

Five steps to improve your reading speed—combined reprint of six-part article. *Circle E 66*

Linkages by Graphical Synthesis

Design of 4-bar linkages to generate specific functions. Feb 2 *Circle E 65*

(Continued on page 141)

3 PULLEY DESIGNS

CONSTANT SPEED — Hi-Lo Automatic Pulleys employ an exclusive cam and cam follower assembly to maintain desired speed ratio over a wide range of load variation. They provide high shock absorbency against sudden changes and eliminate "drag" due to temporary overload. Sizes: ¾ to 5 hp. at 1750 rpm. Speed ratios: 1.75 up to 2.6 to 1. *Request Bulletin A458.*

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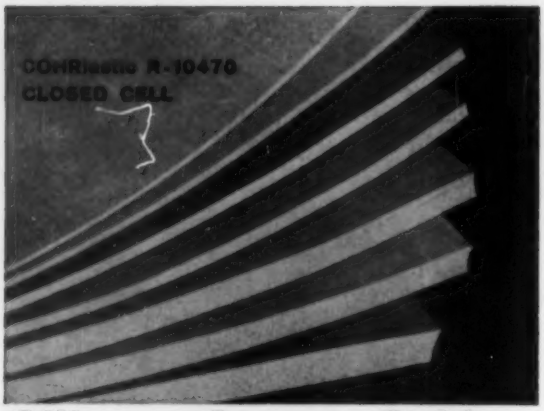

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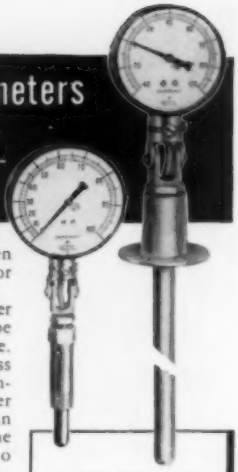

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Solution by Analogy

What makes analog computers different from digital types? Jan 26 *Circle E 63*

Roll Cams—Stop and Go on Demand

Graphical method for designing simple mechanisms that give a prescribed motion when triggered. Jan 19 *Circle E 62*

Which Fhp Motor for the Job?

Applications and costs charted for a simpler way to pin down the right electric motor. Jan 19 *Circle E 61*

With What Do the Russians Weld?

Latest Soviet techniques—electro-slag, submerged-arc, and stored-energy welders. Jan 19 *Circle E 60*

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New extra compact 1/50 hp Servotran mechanical servo

This new, compact 1/50 hp Servotran is only two inches square. Although it is no larger than an ordinary gear box, it provides output shaft speeds infinitely variable over more than a 100 to 1 range, forward and reverse. It is ideal for use in automation equipment, recorders, machine tool feeds, etc.

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ADVERTISEMENT

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS,** *President*
New Hampshire Ball Bearings, Inc.

WHY CLASS ABEC 7 BEARINGS?

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An item-by-item comparison of ABEC 5 and ABEC 7 standards clearly shows how closer tolerances improve running quality.

(COMPARATIVE CHART)

RING		MEASUREMENT	TOLERANCES ABEC 5	TOLERANCES ABEC 7
Both	1.	Radial Runout (TIR) Max.	.0002"	.0001"*
Inner	2.	Side Runout with Bore	.0003"	.0001"
Outer	3.	O.D. Runout with Side	.0003"	.00015"
Both	4.	Parallelism of Sides	.0002"	.0001"
Inner	5.	Groove Parallelism with Sides	.0002"	.0001"
Outer	6.	Groove Parallelism with Sides	.0003"	.0002"
Inner	7.	Bore (I.D.)	+.00000" −.0002"	+.00000" −.00015"
Outer	8.	O.D.	+.00000" −.0002"	+.00000" −.00015"
Both	9.	Width (Individual Rings)	+.000" −.005"	+.000" −.001"**

*ABEC 7 allows .0002" radial runout for outer ring. We hold it to .0001".
**ABEC 7 allows −.005".

Radial Runout . . . the sum of a ring's out-of-roundness and eccentricity . . . is functionally important. In critical high-speed applications, it affects balance and true running. In precise gear trains, it affects backlash and sometimes angular velocity ratio. In closely designed synchros and similar electrical equipment, it affects air gap control. Since most bearings operate with inner ring rotation, you'll notice that ABEC 7 cuts the ABEC 5 allowance in half . . . from .0002" max. to .0001". For the outer ring ABEC 7 makes no change from Class 5's .0002" max. However, modern race grinders work to a nominal zero runout and .0001" max. may usually be expected. Our inspection tolerance, therefore, is .0001". This gives outer-ring rotation applications the same advantages as for inner-ring rotation.

Perpendicularity of raceway planes to axis of rotation is a highly desirable feature. Its probability is determined by the interrelationship of Side Runout with Bore (Inner Ring), O. D. Runout with Sides (Outer Ring), parallelism of sides and groove parallelism with sides of both rings, when bearings are properly mounted and seated. If raceway planes are not perpendicular to the axis of rotation, stresses and torque peaks will be developed within the bearing because of this misalignment unless radial clearance and enlarged raceway curvature are sufficient to compensate. This effect may be observed in clamped, preloaded duplex bearings by shifting the relative position of the rings, reclamping and feel-testing.

Notice that the five perpendicularity features (2 through 6 in the chart) have much lower allowances in ABEC 7 than in ABEC 5. These differences in angular inaccuracy mean much in running quality as bearings become smaller. For example, non-parallelism of .0002" on a ⅜" O.D. (R 2 bearing) represents an angular error of about 2 minutes. But, on a 3/16 O.D. (R 1 bearing), the same allowance means 4 minutes of angular error. That's why ABEC 7 reduces allowances by one half or more. The importance of minimizing angular error is also reflected in the AFBMA tables of allowances, which are generally reduced within each class as size of bearing is reduced.

Envelope Tolerances (7, 8, and 9 in the chart) make little or no difference in running quality. The only ABEC change is from bore tolerance of plus 0, minus .0002 in Class 5 to minus .00015 in Class 7. This permits mounting bearings to a narrower spread of fits. Although ABEC 7 allows the same O.D. and width tolerances as for ABEC 5, we have reduced O.D. tolerance to plus zero, minus .00015" and, together with other manufacturers of instrument bearings, have reduced width tolerance to minus .001. The latter minimizes variation in axial spacing of assemblies.

Other Factors that affect running quality of bearings are not covered by ABEC standards. They include: truth of raceway geometry, surface finishes, retainer design and finish, radial and axial play and some ball qualities. These are discussed in our design handbook.

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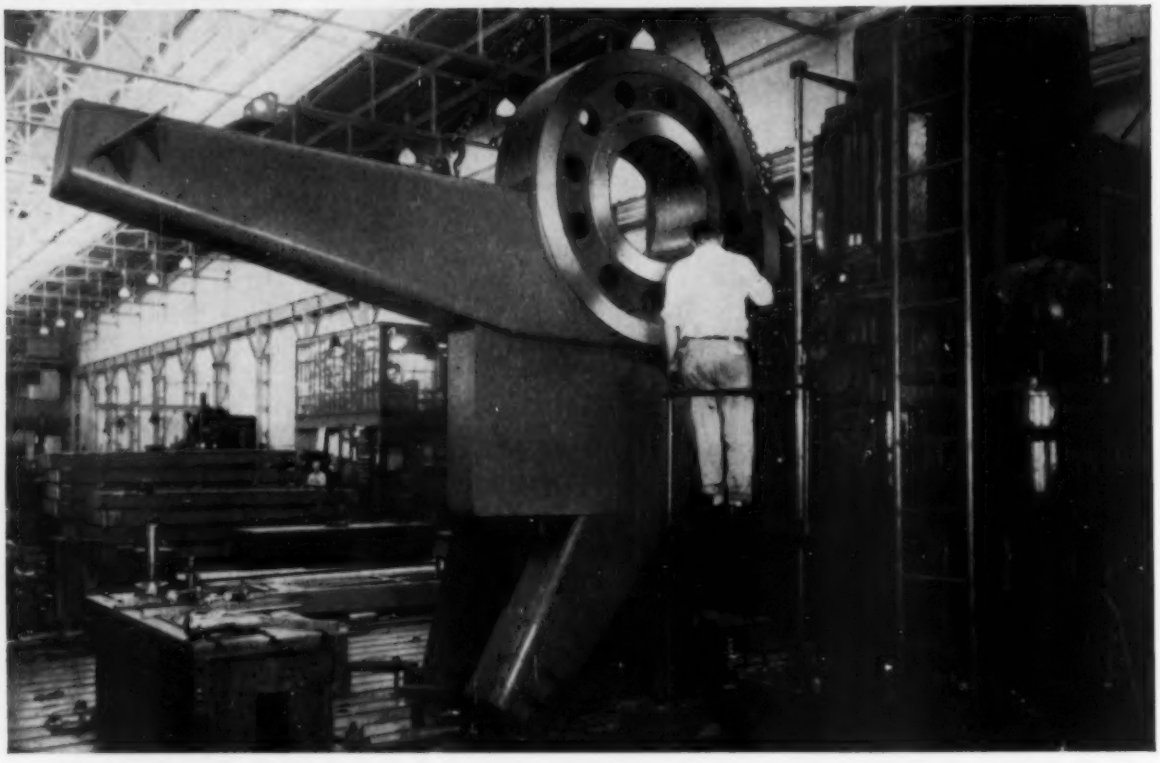

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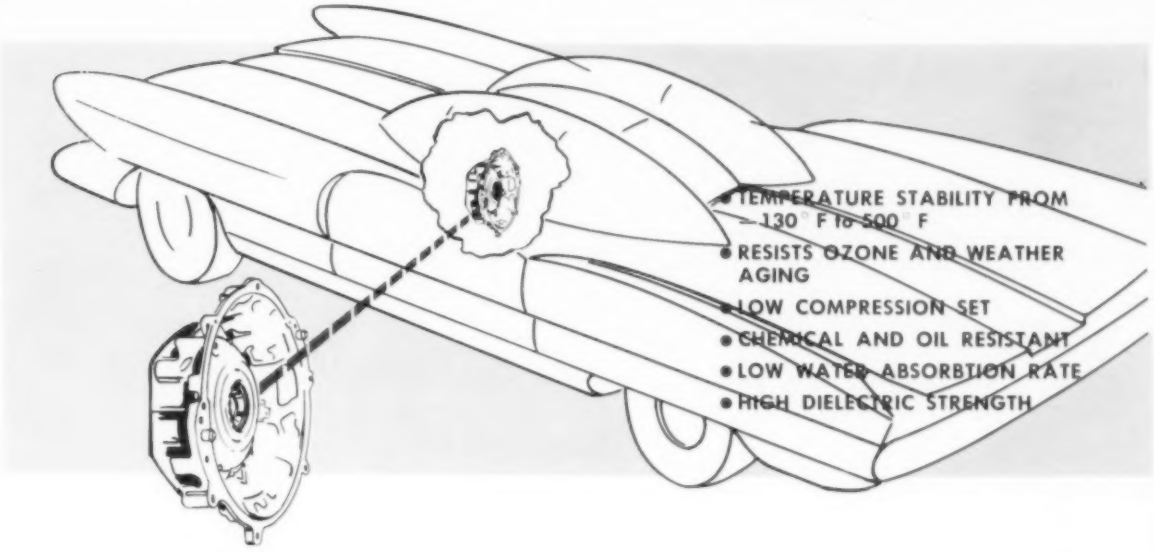
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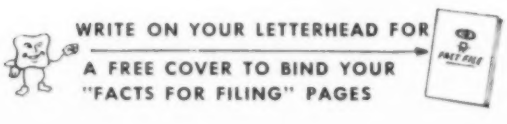

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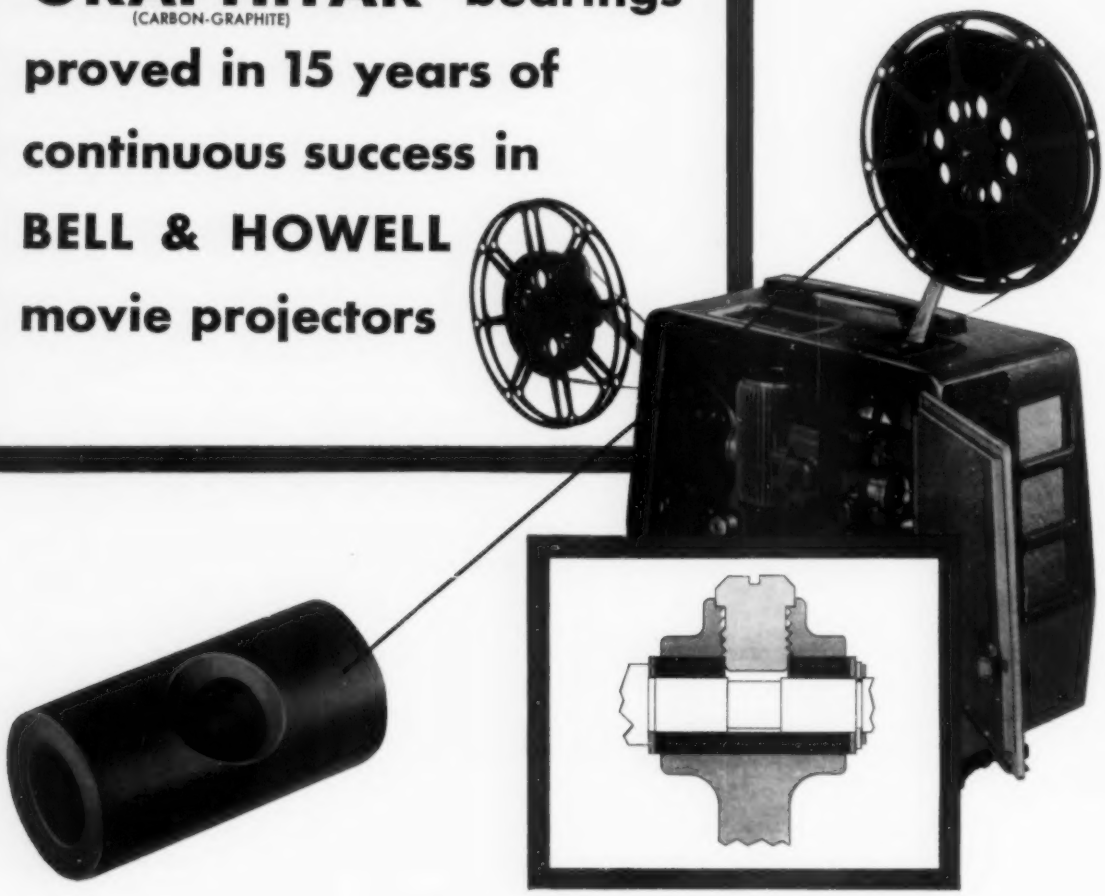

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